The Ecologist

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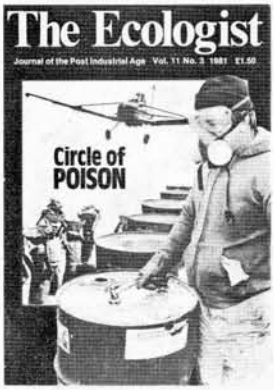

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Editorial

Feature Articles

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Editorial

Rationalising the Impossible

Before making a major decision, Oliver Cromwell used to closet himself away — sometimes for hours, sometimes for days — and wait for God to reveal the course He wished him to take. Apparently cynics used to say that, whilst one could always predict Cromwell's decisions in advance, it was singularly unsafe to bet on which biblical quotes God would tell him to use in order to justify them. Indeed, it is said, that if Cromwell changed his mind, he would frequently cite the same passages to justify his U-turn as he originally cited to back up the decisions he was overturning.

I was reminded of Cromwell when I read *Shaping Tomorrow,* the Methodist Church's latest report on science, ethics and the future. Written by a committee of scientists and engineers (sixteen of whom work at Harwell or other nuclear establishments), the report is essentially a call to Christians to throw their muscle behind such technologies as genetic engineering, nuclear power and the microchip. "The Christian church", the authors tell us, "must not let the technological Revolution pass it by. There is a vital role for Christian people to play in shaping patterns for the future. Technology gives mankind huge muscles, vast calculating power and stores of information that makes it easy to undertake projects which were formerly impossible. The new power brings with it the risk of misuse but, more importantly, it opens up immense opportunities for good. We believe that Christians must seek to identify where God wills that we should be going and then we must throw our strength into the struggle, alongside Him, to make it happen." Elsewhere, the Reverend William Gowland, Principal of Luton Industrial College, warns that "It is vital that the Christian Church should not arrive when the battle is over to bury the dead." Given the nature of the technologies he is urging up to adopt, one wonders if he was aware of the irony of his words.

I have to admit that my first reaction to the report was one of stupefaction. Here was a bunch of scientists bent on proving that God was really a scientist and that since scientists are now gods, they should be allowed to take over where He left off. For them, genetic engineering brings the possibility of "an era of man as creator of life" — an era which Christians should welcome as "one of the things which makes life an adventure." Nuclear energy is "a key part of the workings of nature" and it is only fear which "prevents many people from seeing it in any sense as an instrument of God's love": indeed, its discovery at the very moment when fossil fuels are becoming scarce should be regarded as evidence "of God's care for mankind." Nor should we have any doubts about the morality of pursuing these 'developments' for the authors have considered the moral issues carefully and, we are told, their deliberations were "based not on their own human wisdom but on God's as authoritively revealed through the scriptures."

Hence my thoughts of Oliver Cromwell — and the reasons why I became increasingly fascinated by the report as I read on. Quite simply, it provides one of the best examples ever of the old adage that 'Man is not a rational animal but a rationalising one.' He will believe anything so long as it is what he wants to believe — even if it involves him in the most tortuous logic, and tortuous logic abounds in *Shaping Tomorrow.*

Indeed, reading the report, one wonders at times whether one is not actually reading a tract *against* the development of nuclear power and all the other technologies the authors are arguing we should accept. We are told, for instance, that "The basic problem is not the technology but man himself. Experience through the ages has shown that he is incapable of living up to his own standards and ideals, let alone those of his creator." So too, we are told, that the authors do not subscribe to "the discredited ideas of inevitable progress, for mankind's march spreads always in two directions. Each step towards the fulfilment of God's purpose seems matched by movement along the other road to perdition." Taken together — or even separately — those two comments would seem to provide ample reason for rejecting the authors' headlong pursuit of the New Technological Revolution. The new technologies carry awesome risks; man is the only instrument for their control; and yet man is too fallible to be relied upon. So should he not be denied such technologies? Is not a ban on their use the only way of preventing otherwise inevitable disasters?

Not so, say the authors of *Shaping Tomorrow* in one of their more formidable U-turns: of course man is fallible, but 'no responsible person' would ever abuse the new technologies. Nor is that the only contradictory statement in the text. Technology is not the problem; yet all technologies carry risks. The creation of wealth is a god-given duty ("The Christian symbolism of the rich harvest, the fruitful vine and the land flowing with milk and honey applies not just to agriculture but to extractive and manufacturing industry too. Its products are equally gifts from God and part of the wealth that we, as his heirs, are to create and can enjoy."): yet the materialism of Western man is to be deplored, as are many other aspects "of industrialisation and the complex growth oriented economy" for the simple reason that they "are not always to the psychological benefit of the workforce, nor to the spiritual well-being of society." Christianity is a positive faith, "founded on love, sacrifice and forgiveness: yet Christians should "avoid" those organisations "based on intolerance, self-interest and opposition to all changes in the existing order" for they "have little to commend (themselves) to those who are truly seeking the kingdom of God." There should be no limits to scientific enquiry: yet (thank God) cloning of human beings should not be pursued "because of the possibilities of abuse which it would present."

Now there is nothing new in the world-view of a particular group containing the most astounding contradictions. But it should be said that the contradictions of the world-view scotches fairly and squarely the claim by the nuclear industry that only its opponents are irrational. What we need to ask, however, is why obviously intelligent men can hold so many completely contradictory statements to be self-supporting.

The truth is that the fundamental premises of their religio-scientific world-view are unverifiable hypotheses: it is for this reason that ecologists are so worried about the implications of the New Technology. We do not know what the risks are — but we do know if we miscalculate then the repercussions are likely to be world-shattering. But the religious men of Harwell *cannot* contemplate that their premises may be open to question. Their paradigm is God-given, revealed to them through the scriptures. To be sure, they treat the scriptures like putty, moulding them to suit their purposes (and each of their biblical quotes could be countered with another) but unless they are able to believe that their interpretation is the right one, then it goes without saying that their world-view will inevtiably crumble around them.

They *have* to prove that technology is God-given — whatever type of technology it may be. And they attempt (albeit laughably) to prove just that. "How far," they ask, "does the Bible see man as a technological animal? The answer is from the very beginning. Man is set to till the ground even in the Garden of Eden, presumably with some form of agricultural implement (Genesis 2 : 15). The Lord himself is seen as the founder of the clothing industry (Genesis 3 : 21); heavy industry makes an early appearance in the form of Tubal-Cain, the forger of all instruments of bronze and iron, (Genesis 4 : 22); shipbuilding comes with Noah's Ark (Genesis 4 : 22) and the construction industry with the erection of the tower of Bable (Genesis 11 : 1-9)." As for the nuclear industry, well, God himself initiated that when he set off that 'natural nuclear reactor' in the Gabon.

And if they have to see man as a natural technologist, then it is still more important that man is seen to have a God-given right to exploit technology, to take risks and to assume that, in the end, those risks are nothing to worry about. "God intends the earth to be a workshop rather than a museum," we are told. And, in any case, "The Christian faith endorses the acceptance of risks as a normal and proper part of a life directed towards the achievement of God's purpose. The very message of Jesus's own life is the willing acceptance of risks in the pursuit of God's loving purpose." And did not Christ tell us the parable of the Talents? "It is not the servant fearing to use his master's gift who is commended but those who take and use productively what they are given;"

So we are given 'carte-blanche' to develop those talents that have led to the splitting of the atom and which may eventually lead us all to being irradiated by it. We have it on the best authority that it is in God's interest for us to do so. Not that we should indentify God with Nature: No, that would never do. Science has shown us that "it is no longer possible on the grounds that every detail was designed by God and that therefore we should respect his handiwork."

I am afraid that is precisely the line I take. I may be misguided but if I identify God with anything it is undoubtedly with Nature. Like J. E. Lovelock, author of *Gaia,* I cannot believe that life on earth is mere coincidence: as he puts it, the chemical and atmospheric properties needed for life to survive are so complex that the likelihood of them occurring by chance is about the same as the likelihood of driving blindfold through rush-hour traffic and surviving unscathed.

No doubt such a view would be dismissed as 'para-primitivism' by the good men of Harwell. I will be accused of 'romancing' (*sic*) nature. But is that not preferable to 'romancing science' — for whatever paradigm I accept on my premises, it is more than likely to be adaptive. And can we really trust the message of scientists who willfully distort the biblical message to marry science and religion? I say 'willfully' because I took the trouble to check some of their biblical references. In particular I was intrigued by their insistence that risk-taking was part of Christian life and duly looked up Mark 8, verse 35. I read and re-read the passage — but could see it justifying nothing other than martyrdom. "For whosoever will save his life shall lose it; but whosoever shall lose his life for my sake and the gospel's, the same shall save it." Perhaps, ' thought, the next verse would help me understand the reference. It didn't: and I could understand why the authors of *Shaping Tomorrow* hadn't quoted it. For it directly contradicted their technophoric message: "What shall it profit a man if he shall gain the whole world and lose his soul?"

I wonder, too, whether the good men of Harwell have ever read Moses' warnings on the consequences of breaking the Ten Commandments. It's not pleasant reading but one passage sticks firmly in my mind: "The Lord shall make the rain of thy land powder and dust: from heaven shall it come down upon thee, until thou be destroyed." It sounds horrifically like the atomic fall-out from one of those reactor accidents that can never happen. Perhaps that is why it doesn't appear in *Shaping Tomorrow.* If I'm right, Cromwell would certainly have approved.

Nicholas Hildyard

NOTICE TO OUR READERS

Our appeal has yielded in the region of £800 and we are extremely grateful to those who have taken out subscriptions or contributed donations. In addition our publisher is putting £10,000 into the magazine. This will reduce our overdraft to a manageable sum. Nonetheless, measures must still be taken to reduce our deficit.

As we make no money on sales through the shops — the majority of which do not stock *The Ecologist* for display but only purchase it when a customer places a regular order — we have decided to sell the magazine on subscription only. To those who have been buying *The Ecologist* through their newsagents, we make an introductory offer of a subscription at the reduced rate of £10 (including postage). This offer closes on January 31st 1982.

To counter the announced increase in postage (coming into effect from January 1982) we are also increasing our subscription rates to £12.50 per annum for individuals; and £18.00 for institutions. The increase will take place on April 1st 1982.

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Fallacies of Life-Style Cancer Theories

by
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If you contract cancer, is it all your own fault? The result of smoking cigarettes or eating too much fatty food? The chemical industry would like us to believe so — but do the facts tally with their figures?

The lifestyle theory of cancer causation postulates that if you get cancer it is essentially your own fault, and that the causal role of past involuntary exposure to environmental and occupational carcinogens is trivial. Not surprisingly, the lifestyle theory has emerged as the major professed basis of the chemical industry's objections to the regulation of its carcinogenic products and processes[1]. As an enthusiastic proponent of this theory, Peto, who reviewed *The Politics of Cancer*[2] in *Nature*[3] and to whom this article is a reply, asserts that smoking-derived and fat-associated cancers "collectively account for more than half of all cancer deaths." As a corollary of Peto's emphasis on lifestyle factors, he denigrates the role of occupational and environmental carcinogens and the need for their effective regulation, claiming that there has been no recent increase in cancer mortality rates other than that due to smoking. We shall demonstrate that there is scant scientific basis for the lifestyle theory, and that it is in fact contradicted by a substantial body of published evidence.

Cancer rate trends

Peto justifies his emphasis on lifestyle factors by dismissing evidence for recently increasing cancer rates, apart from "that due to the massive effects of smoking on lung cancer". However, there is substantial evidence to the contrary. Standardized cancer death rates, adjusted to the 1940 age structure of the total United States population, show a progressive overall increase of about 7% from 1935 to 1970[4] despite marked reductions of stomach cancer rates for unexplained reasons and of cervix cancer rates for reasons including the frequency of elective hysterectomy for non-malignant disease and the success of screening programmes. These trends are consistent with standardized mortality data for the United States (Table 1)[5], where they are even more marked in black males, and with crude mortality data for the United Kingdom (Table 2)[6]. The overall rate of increase in US cancer mortality in the 7-year period from 1969 to 1976 (5.5%), adjusted to the 1970 age structure, is substantial and comparable with that for the preceding 35 years, 1935 to 1970 (7%). The overall increase in incidence rates is even more marked than mortality rates in the past decade, involving a wide range of organs besides the lung (Table 3)[5]. Moreover, the increase in incidence for all sites is comparable with that when lung cancer is excluded (Table 4)[7,8].

Reliance on overall age-adjusted incidence or mortality rates alone is simplistic, as such rates can mask steep increases in organ-specific cancers in high risk population subgroups, such as asbestos insulation workers or menopausal women treated with oestrogen replacement therapy. The overall probability, at today's death rates, of a person born now getting cancer by the age of 85 is 27% for both men and women; this is increased from the 19% for men and 22% for women born in 1950[9]. Furthermore, recent cancer rate trends reflect exposures and events beginning some 20 or 30 years ago, when the production of synthetic organic chemicals was relatively trivial compared with the present levels. The production of synthetic organic compounds in the United States in 1935, 1950 and 1975 was about one, thirty and three hundred billion pounds per annum, respectively[10]; sharp increases have also been observed for a wide range of derived industrial products such as chlorinated hydrocarbon solvents, plastics and resin materials, and of industrial carcinogens, such as vinyl chloride and acrylonitrile. It is reasonable to anticipate that greater production has been paralleled by increased exposure of increasing numbers of both the workforce and the general public, which is likely further to accentuate increasing trends in cancer rates. It must also be recognized that before the 1976 Toxic Substances Act, which the chemical industry so effectively stalled for so long[11], there were no requirements for testing chemicals before their introduction into commerce (with the exception of special-purpose legislation for drugs, pesticides and food additives). Thus, the overwhelming majority of industrial chemicals now in use have never been tested for chronic toxic and carcinogenic effects, let alone for ecological effects.

Role of smoking

As emphasized in *The Politics of Cancer*[1], "Smoking is the single most important cause of lung cancer, as well as of cancer at other sites, chronic bronchitis and emphysema, and cardiovascular diseases". Less well appreciated by lifestyle advocates is that over-emphasis on smoking is widely used to divert attention from occupational causes of lung and other cancers. Of the approximately 100,000 annual lung cancer deaths in the United States, at least 20% occur in nonsmokers. It is relevant that lung cancer death rates in nonsmokers approximately doubled[12] from 1958 to 1969, an increase maintained since. Furthermore, the role of occupational exposure to carcinogens was not recognized in most of the classic epidemiological studies which linked lung cancer with smoking. This led to overestimation of the contribution of smoking compared with occupational risks or to their possible interactions.

Thus, "we are unable to say how much of the risks attributed to cigarettes is a 'pure' cigarette risk and how much is cigarette times another, possibly on the job hazard". Moreover, smoking and occupation are confounded variables, smoking among men being more prevalent in 'blue-collar' workers than in professional and managerial classes[13]. Occupational causes of lung cancer include asbestos, radon daughters, nickel ores, chromium, arsenic, beryllium, mustard gas, vinyl chloride and bischloromethyl ether, apart from incompletely identified carcinogens in a wide range of industries such as rubber curing, tanning, steel (coke ovens), foundries, automobile, and petro-chemicals. Thus, lung cancer rates in asbestos insulation and topside-coke oven workers are as much as 10 times greater than general population rates.

Underestimation of the role of such occupational carcinogens has been assisted by the fact that lung cancer mortality rates, based on the International Classification of Diseases, fail to distinguish pleural mesotheliomas from lung cancers; there is evidence of substantial under-reporting of mesotheliomas (by about 75%) in high risk groups[14], and even more so in occupations, such as automobile mechanics, where asbestos exposure has not been well recognized. There is a further lack of distinction between lung cancers of different histological types, some of which, such as adenocarcinomas, are less likely to be due to smoking than to occupational carcinogens[15,16]. "In several instances where the risk of bronchogenic carcinoma has been shown to be increased among occupationally exposed groups, there has been an accompanying shift in the distribution of histologic types of tumours", away from the small-cell undifferentiated and squamous cell carcinoma of the lung, the principal types whose frequency is increased by smoking, in the direction of other types, particularly adenocarcinoma. "This (shift) has been noted among metal miners, uranium miners, copper smelter workers, vinyl chloride polymerization workers, chloromethyl methyl ether production workers, and mustard gas manufacturers"[16].

Possible variations of smoking patterns fail to account for the marked excess in US lung cancer rates identified in specific occupational exposures, particularly among ethnic minorities and migrants from southern states[17]. A further challenge to the dominant role ascribed to smoking seems to be provided by observations that the risk of lung cancer in certain occupational groups, such as American Indian uranium miners[18], Swedish zinc-lead miners[19], mustard gas workers[20], copper smelters exposed to arsenic[21], and chloromethyl methyl ether workers[22], is about as high among nonsmokers as smokers, although the latency period is reduced in smokers, suggesting a

Table 1 Age-adjusted cancer mortality rates per 100,000 US population for selected sites by sex and year 1969-76, and average per cent change.[5]

		Mortality rate per 1000,000		Average % change 1969—76	
Site	Sex*	1969	1976	Annual	7—Year
All sites	WM	195.0	210.2	0.9	7.8
	WF	129.0	133.8	0.5	3.7
Stomach	WM	10.6	8.7	−2.9	−17.4
	WF	5.3	4.1	−3.6	−22.6
Colon	WM	18.7	20.7	1.3	10.7
	WF	16.2	16.5	0.0	1.9
Rectum	WM	6.9	5.6	−3.0	−18.8
	WF	3.9	3.2	−3.1	−17.9
Pancreas	WM	11.0	11.0	0.0	0.0
	WF	6.6	6.8	0.3	3.0
Lung	WM	55.0	66.7	2.6	21.3
	WF	10.2	17.8	7.6	74.5
Melanoma	WM	2.0	2.6	4.0	30.0
	WF	1.4	1.6	0.8	14.3
Breast	WF	26.2	27.2	0.3	3.8
Cervix	WF	5.5	3.9	−4.9	−29.1
Uterus	WF	4.6	4.2	−1.7	10.5
Prostrate	WM	19.0	21.0	−1.2	8.7
Bladder	WM	7.1	7.5	0.6	5.6
	WF	2.1	2.0	−1.4	−4.8
Kidney	WM	4.3	4.5	0.6	4.7
	WF	2.0	2.1	0.7	5.0
Leukaemia	WM	9.4	9.2	−0.4	−2.1
	WF	5.7	5.2	−1.7	−8.8

For age adjustment the 1970 United States was used as standard *WM, white male, WF white female.

Table 2 Crude cancer mortality rates per 100,000 population for selected sites by sex and year, England and Wales, 1971-77, and average per cent change.[6]

		Mortality rate per 100,000		Average % change 1971—77	
Site	Sex	1971	1977	Annual	6-Year
All sites	M	265	283	1.1	6.8
	F	215	233	1.3	8.4
Stomach	M	30	28	−1.2	−6.7
	F	21	19	−1.7	−9.5
Large intestine & rectum	M	30	32	1.1	6.7
	F	34	35	0.4	2.9
Respiratory	M	106	112	0.9	5.7
	F	22	29	5.3	31.8
Breast	F	45	47	0.7	4.4
Uterus	F	15	16	1.1	6.7
Prostate	M	17	19	1.9	11.8
Bladder	M	12	12	0.0	0.0
	F	4.1	5.1	3.7	24.4
Leukaemia	M	7.0	7.2	0.4	2.9
	F	5.5	6.0	1.5	9.1

Table 3 Age-adjusted cancer incidence rates per 100,000 US population (whites) for selected sites by sex and year, 1969-76, and average per cent change.[5]

		Incidence rate per 100,000		Average % change 1969—76	
Site	Sex	1969	1976	Annual	7—Year
All sites	M	346.6	374.0	1.3	7.9
	F	271.5	301.2	2.0	10.9
Stomach	M	15.4	12.6	−2.3	−18.2
	F	7.1	5.6	−3.7	−21.1
Colon	M	34.5	36.9	1.5	7.0
	F	30.6	31.4	0.7	2.6
Rectum	M	17.5	19.4	1.3	10.9
	F	11.1	11.4	1.2	2.7
Pancreas	M	12.1	11.5	−0.5	−5.0
	F	7.5	8.0	0.9	6.7
Lung	M	70.6	77.8	1.4	10.2
	F	13.3	23.7	8.6	78.2
Melanoma	M	4.4	6.8	6.8	54.5
	F	4.1	6.1	6.2	48.8
Breast	F	73.9	83.5	1.8	13.0
Cervix	F	16.0	10.6	−5.9	−33.8
Uterus	F	22.6	31.2	5.9	38.1
Ovary	F	14.9	13.6	−0.4	8.7
Prostate	M	59.0	68.9	2.3	16.3
Bladder	M	23.8	26.4	2.3	10.9
	F	6.3	7.3	2.5	15.9
Kidney	M	9.0	9.6	1.2	6.7
	F	4.3	4.8	1.3	11.6
Leukaemia	M	13.2	13.1	−0.2	−0.8
	F	8.0	7.1	−1.0	−11.3

The 1970 population was used as standard for age-adjustment.

Table 4 Changes in US cancer incidence rates from 1970 to 1975[7,8]

	Average % increase in incidence rates, 1970-75			
	Cancers of all sites		Cancer of sites except lung	
Groups	Annual	5-Year	Annual	5-Year
White male	0.9	4.7	0.9	4.6
Non-white male	2.3	11.9	2.7	14.3
White female	2.2	11.6	1.8	10.2
Non-white female	6.1	34.6	5.7	32.2

Table 5 International correlations between breast, colon and liver cancers and possible aetiological variables[26]

	Correlation coefficient			
	Consumption of fat	Consumption of animal protein	Gross National Product	Total energy production
Breast cancer				
Incidence	0.79	0.77	0.83	0.70
Mortality	0.89	0.83	0.72	0.60
Colon cancer (M)				
Incidence	0.74	0.74	0.81	0.68
Mortality	0.85	0.86	0.77	0.69
Colon cancer (F)				
Incidence	0.78	0.80	0.82	0.67
Mortality	0.81	0.84	0.69	0.62
Liver cancer (M)				
Incidence	−0.49	−0.59	−0.42	−0.25*
Liver Cancer(F)				
Incidence	−0.59	−0.67	−0.53	−0.31*

* 'Liquid energy'

possible promotional effect of smoking. It appears that the relative risks of lung cancer for smokers as against risks for nonsmokers may have been overestimated, particularly in less than lifetime studies[13]. Variations in smoking do not account for geographic excesses in lung cancer rates in US males and females, which overall reflect proximity of residence to petrochemical and certain other industries[23,24]; there are also data showing associations between levels of atmospheric carcinogens and lung cancer mortality rates[25]. It may be noted that a report[26] from Peto's own institution demonstrates that the correlation coefficient between lung cancer and smoking internationally explains only one-third as much of the variation as does the correlation between lung cancer and solid fuel consumption (0.4 versus 0.7;$r^2 = 0.16$ versus 0.49).

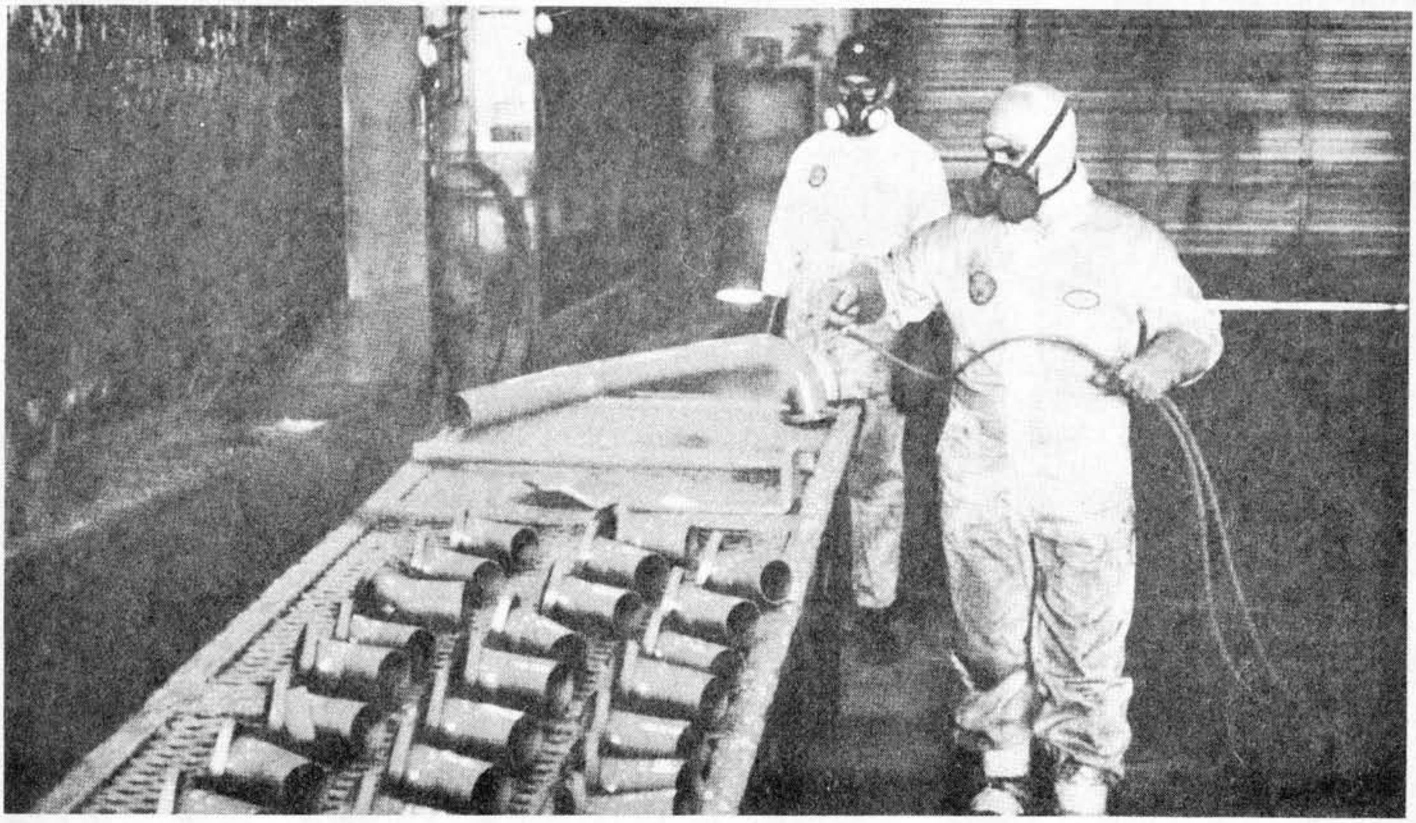
Overemphasis on the carcinogenic effects of smoking, and ignoring or discounting the role of occupational and other exposures, is extended by Peto and others to cancers of the bladder and pancreas which are variously characterized as related to or caused by smoking[27,28]. However, the relative risks for these cancers are several times less in smokers compared with nonsmokers than is the case for lung cancer. Excess bladder cancer rates have been identified in several occupational categories, including rubber, paint manufacturing and textile dyeing workers[29], and among residents in highly industrialized counties[30], particularly those with large chemical industry complexes[31]. Excess pancreatic cancer rates have also been reported in various occupations including steel and metal workers[32] and organic chemists.

Recognition of the important role of occupational exposures in lung cancers previously ascribed, exclusively or largely, to smoking in no way detracts from the recognition, emphasized in *The Politics of Cancer,* that the impact of smoking constitutes a "national disaster". There is no basis for regarding the smoking/lifestyle and occupational theories as mutually exclusive, particularly as these exposures may operate interactively. Furthermore, lifestyle is a somewhat misleading rubric for smoking as it restrictively implies voluntary personal choice. Placing responsibility for personal choice of an addictive lethal habit on young teenagers, the fastest growing group of new smokers, seems inappropriate. Failure to control smoking reflects a wide range of political and economic constraints, including massive press advertising by the industry which omits the word 'death' from the guarded small print warning of danger, massive revenues to federal, state and local government from tobacco taxes, federal subsidies to the industry and unwillingness of governments to increase tobacco taxation or to develop incentives to tobacco farmers to diversify. It is also important that the industry has moved to open up massive new markets with high-tar cigarettes in less developed countries, where the population is poorly informed on the hazards of smoking.

Role of Dietary Fat

Lifestyle proponents are on less sure ground when they bracket diet, excess fat and overnutrition with smoking as the causes of the majority of cancer deaths. This claim is based largely on international correlations between consumption of total fat and rates for cancer of the breast and colon[26]; however, such correlations by themselves are not proof of causality. Similar correlations were found, in the same study from Peto's institution, between breast and colon cancers and other variables, such as Gross National Product and consumption of animal protein, which also appear to reflect industrialization[26] (Table 5). Furthermore, "epidemiologically, the case against fat is weak because there are populations that have a high fat intake and little bowel cancer . . .[33]" Of two case control studies on the association between diet and breast cancer, one found no effect[34] and the other found trivial effects of fat and caloric intake, concluding that ". . . recommendations of major dietary modification as a possible preventive measure for breast cancer are clearly premature".[35]

Equally unconvincing are the studies, cited by Peto as corroborative evidence on the experimental effects of diet, which were largely concerned with the influence of fat on the incidence of tumours induced by chemical carcinogens and ionizing radiation, and the influence of caloric intake on the incidence of spontaneous and induced tumours. Not only were different variables defined in the animal and human studies — per cent fat in the diet and total dietary fat, respectively — but increasing fat levels in the animal experiments were associated with increased incidence of skin, liver and breast cancers, whereas the reported correlations between fat consumption and liver cancer



mortality are negative for both men and women (Table 5). Moreover, these experiments often failed to differentiate between variations of total dietary fat and caloric intake in test animals and to adjust caloric intake in controls to reflect dietary fat variations in test animals; the magnitude of the variations in fat and caloric intake required substantially to influence the incidence of induced and spontaneous tumours in experimental animals is generally far in excess of the dietary differences observed among the various human populations studied.[33] These experiments invariably failed to adjust the intake in controls of fat soluble carcinogens, present in fat as accidental environmental contaminants, to reflect variations of fat intake of test animals.

Peto's claim for the causal role of dietary fat in human cancer overstates the conclusions of those cited as the basis for his claims. Armstrong and Doll[26], for instance, merely suggest that dietary fat levels may influence the incidence of colon and breast cancers, without asserting causality. Doll considers that diet may act by modifying the incidence of tumours induced by carcinogens or by acting as a vehicle for exogenous carcinogens[36] — a suggestion also made in *The Politics of Cancer* which Peto dismisses as "implausible". Carrol concludes that "although caloric intake may be a factor in human carcinogenesis, it does not appear to offer a practical approach to the problem"[37]. As recognized by current concepts on the multifactorial aetiology of cancer, there is a substantial probability that a wide range of influences, diet and other lifestyle factors included, modify individual responses to carcinogenic agents. To ascribe causality to any particular modifying factor requires a degree of scientific evidence that has not yet been presented for dietary fat.

Role of occupation

Peto associates himself with the insistence by the chemical industry and other lifestyle proponents that occupational exposures account for about 5%[38,39,40] or "a very small proportion"[41] of all cancers. This view is based on ascribing given percentages to known or alleged lifestyle factors (including smoking, fatty diet and sunlight) leaving a small unaccounted for residue to which occupational factors are arbitrarily assigned by exclusion. The authors of this simplistic hypothesis compensate for its tenuous basis by reliance on 'educated estimates' and by making circular references to each other, often by 'personal communication', as the responsible authority.

However, there are problems with such 'guesstimates'. First, they fail to consider the multifactorial aetiology of cancer and the role of multiple causal agents, such as asbestos and smoking[42]; thus, the summation of known causes of cancer should properly exceed 100%. As one of the lifestyle authors recently stressed,[36] "there is now strong evidence to suggest that the risk of cancer is commonly increased by interaction of two or more factors". Second, current cancer rates reflect exposures 20 to 30 years ago, when production levels of occupational carcinogens were a small fraction of the present; such estimates should thus now be adjusted to reflect increasing numbers of workers exposed. Third, the authors of these guesstimates fail to consider the very limited nature of the data base on exposure to occupational carcinogens. Nor have they at any stage protested or even commented on the persistent refusal of the chemical industry to make such critical data available. In the absence of exposure data, it is even less clear how the 'lifestylers' confidently arrive at their estimate of less than 5%.

"Overemphasis on smoking is widely used to divert attention from occupational causes of lung and other cancers."

Rather than addressing himself to such problems, Peto dismisses recent estimates of the importance of occupational carcinogens in a report by the US Public Health Service[43] as exaggerated, unsound and unreasonable. This report, prepared by nine named and internationally recognized experts in cancer epidemiology, statistics and carcinogenesis from three federal research agencies, is based on a National Occupational Hazard Survey which between 1972 and 1974 surveyed nearly 5,000 workplaces chosen to provide a cross-section of industry in the United States. The report estimated the total number of workers exposed to asbestos, nickel ores, chromium, arsenic, benzene and petroleum fractions, including aromatics. The excess cancers attributable to each of these carcinogens were derived by multiplying the number of exposed workers by known risk ratios and subtracting the "normal incidence" of the cancer.

The report concluded that "as much as 20% or more" of cancers in the near term and future may reflect past exposure to the six carcinogens considered. The uncertainties and limitations in these conclusions, including the possibility that exposures and risk ratios may have been overestimated in some instances, were clearly stated in the report, as were other considerations including the multifactorial aetiology of cancer, and the role of lifestyle factors and their possible interactions with occupational exposures.

The possibility that this government report underestimates rather than overestimates the role of occupational exposures, for several reasons some of which are recognized in the report, has not been considered by its denigrators, including Peto. First, the calculations in the report ignore the role of radiation and of some ten epidemiologically recognized occupational carcinogens, other than the six considered. Second, the risk ratios considered may be artificially low as they were largely derived from less-than-lifetime epidemiological studies[44], which may thus underestimate the true risk in view of the long latencies commonly involved. Third, the report does not consider the many statistical and methodological constraints common to most occupational epidemiological studies such as relatively small numbers of workers in many locations, changes in exposure patterns over time due to employee turnover, plant shutdown, process and production changes and changes in management, all of which lead to fragmentation of health and exposure records, access to which is often restricted by industry. Fourth, the estimates fail to take account of the many chemicals recognized as carcinogenic in animals for which there are no exposure or epidemiological data. Thus, of 442 chemicals and industrial processes recently evaluated by the International Agency for Research on Cancer (IARC), epidemiological data are available for only 60 (14%), although evidence of experimental carcinogenicity was considered to be sufficient for 143 (32%)[45]. Fifth, the estimates exclude high risk occupations with incompletely defined carcinogens, such as the steel, rubber and tanning industries. Sixth, the estimates do not adequately reflect conditions in small businesses where exposure levels are likely to be higher than in major chemical companies. Seventh, the report does not reflect major increases in the production of the occupational carcinogens it considered such as benzene, with the likelihood of recently increasing exposures. Eighth, the study examined only a limited number of sites, excluding cancers such as skin and bladder which are known to be occupationally related. Finally, the estimates neglect the possible role of fugitive point-source emissions of industrial carcinogens as causes for the excess of overall and organ-specific cancers, including lung, bladder, colon, pancreas and breast, in residents of certain highly industrialized counties.

This government report has received extensive support from various expert bodies, such as the Toxic Substances Strategy Committee[46], whose position has been endorsed by 17 federal agencies, and international groups, such as the International Labor Organization, and the US and British trades unions. The report has also received additional support in the critique of two consultants to the chemical industry's American Industrial Health Council which concluded that "... the full range (of total cancer attributable to occupational exposure) using multiple classifications may be from 10 to 33% or perhaps higher if we had better information on some other potentially carcinogenic substances ... The annual number of cancer deaths attributable to asbestos is in the range from 29,700 to 54,000, which corresponds to a percentage range of the total cancer of 7 to 14% ... Any argument over these numbers cannot detract from the fact that asbestos exposure was, as the authors (of the Government report) state, a major public health disaster ... We also believe that reduction of exposure to carcinogens in the course of employment can certainly be expected to affect major reductions in the frequencies of occurrence of cancer and is one of the most promising applications of preventive medicine"[47]. The American Industrial Health Council failed to release this critique until the record of the recent Occupational Safety and Health Administration hearings on regulation of occupational carcinogens closed.

Finally, there is no basis whatsoever for recent unsubstantiated allegations by Peto and others that all or most authors of the government report have disowned or rejected it or its conclusions (K. Bridbord, M. Schneiderman and A. Upton, personal communication). It should be further emphasized that this 50-page report was prepared as a government document specifically for inclusion in public hearing records, and not for submission to a scientific journal.

Conclusions

Cancer is a disease of multifactorial aetiology to which occupational exposure and smoking can contribute importantly, sometimes interactively. There have been substantial recent increases in cancer rates which cannot be accounted for by smoking alone. Smoking is the major lifestyle factor of importance in cancer, and evidence for the causal role of other lifestyle factors particularly dietary fat, is slender. The role of lifestyle factors has been exaggerated, by those with an economic or intellectual investment in this theory, by largely excluding involuntary exposures to carcinogens and minimizing the role of occupational carcinogens. These considerations further illustrate the primary thesis of *The Politics of Cancer:* cancer is esentially a preventable disease which requires intervention and regulation at several levels, particularly the occupational and smoking. Failure to prevent cancer reflects major political and economic constraints which have hitherto been largely unrecognized or discounted.

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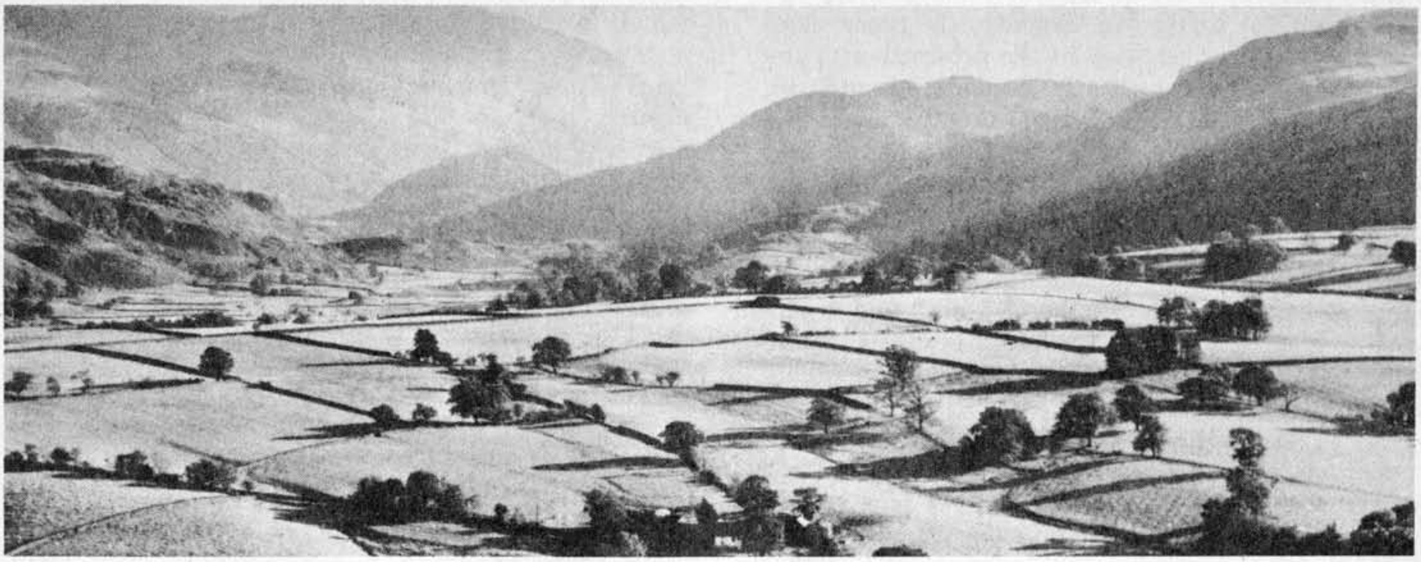

The Case for Hedgerows

by

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Every year, some four thousand miles of British hedgerows are 'grubbed up' in the name of greater efficiency. But whilst their removal makes for easier mechanised farming, the effects on wildlife and agricultural yields are frequently to the farmer's disadvantage.

At first sight the disappearance of hedgerows appears to be due mainly to the need for modernisation in farming. This is a phenomenon which has been particularly clearly observed in France and Great Britain. Without going into statistical details, one can point to the general shrinking of the labour force, the spread of mechanisation, the adoption of "industrial" methods, and the growing of crops by means of fertilizers on land that was formerly left untilled.

From the outset we shall have to approach these factors very differently depending on whether stock farming or crop farming predominates. It would be wrong, however, to draw an absolute distinction in this respect, since with the exception of a few highly specialised types of countryside (the Beauce and Berry region of Champagne for example), no area is committed once and for all to a particular type of farming, and it would be dangerous to take any irreversible action which would impede subsequent conversion. Moreover, the main patters of variation and distribution as between stock farming and crop farming appear to differ from one place to another: Western France is witnessing an increase in dairy farming, while the opposite is happening in Eastern England, and there has recently been a significant expansion in maize growing.

European agriculture was bound to change for several obvious reasons. Technical advances, the design of ever more efficient and ingenious machinery, the availability to fertilizers and the need to produce more for an increasingly urban population — these are the basic factors, even though they need to be qualified to take account of the effects of over-population.

The technical advances, moreover, came at a time when any farming was becoming impossible without them; the background was the drift away from the countryside and the shortage of labour, both of which factors are becoming more and more pronounced. Also, the desire to obtain a standard of living supposedly on a par in towns that explains the taste for leisure and spare time, which it was hoped the acquisition of efficient modern equipment would bring.

These trends are generally considered an inexorable and unavoidable part of the general process of urbanisation in Europe. With the rural population constantly dwindling, the only hope of maintaining production levels lies in constant technical improvement, it being hoped that there is no absolute limit to this development.

We have therefore witnessed an extremely rapid transition from traditional farming to industrial or semi-industrial types of agriculture. Hand in hand with the spread of these methods has gone the grubbing up of hedges, so that some people have been led to believe that the phenomenon is inevitable and irreversible.

It would, however, be as well to ascertain whether this correlation is really a cause-and-effect relationship or simply a coincidence.

Nevertheless, it should be noted that the main lines of change in farming methods sometimes deviate in points of detail: the industrial kind of farming establishes itself to a greater or lesser degree depending on the quality of the soil, the relief characteristics, the climate etc., and there will in any event continue to be areas where production patterns have to be modified. It is already clear that these are the situations in which the hedgerow landscape best holds its own (the Northern Creuse, the Bourbonnais and Western Britain, for example). Should we then accept the argument that the hedgerow landscape areas are unsuitable for highly modernised crop growing and stock farming?

To a certain extent this interpretation is attractive, for an area which by reason of its soil characteristics is unsuited to intensive farming is not affected by the destructive processes inherent in such farming. But the question remains whether the modernisation of a potentially highly productive region depends on the cutting down of hedges, and whether such destruction is indeed the inevitable sequel to the process of improving productivity.

If we look at the question from this point of view, we shall find, to begin with, that an essential decision was dodged at the time when the new techniques became indispensable. New machines were produced, new products designed and the minds of opinion leaders made up on the unconscious assumption that it was not possible to design machinery to work economically on smaller areas of land less devoid of any natural features. The areas worked would, in any event, have been larger than traditional fields, but if an effort had been made to adjust the machine and the ecological balance to each other, a considerable restraint would have been placed on the disintegration of natural environments in the countryside. This idea is difficult to put into practice but contains a wealth of unexplored possibilites; however, it has never been considered, as if it were a foregone conclusion that when a problem arose the natural environment alone should bear the burden of adjusting to it, not those who design, manufacture or sell the technical instruments of an evolution which is indeed necessary and inescapable.

It looks very much, therefore, as if reasons of a more sociological and psychological character underlie the technological causes. The compilations of ecological and agronomic data made so far, which all seem to point in the same direction, suggest that consideration of technical factors alone in crop-farming areas would probably have resulted in a noticeably broader mesh of hedgerow patterns, the widening or remaking of some main paths, the enlarging of field entrances and the disappearance of groups of very tall trees which cast too much shade, particularly in the middle of fields. The outcome would have been a looser landscape structure, with hedges consisting of small or medium-sized shrubs and with fairly few big trees, the whole being incorporated into a renovated communications network — in other words, not the status quo (except where it already provided a proper balance), but moderate, controllable evolution.

Too often the debate over hedges has been clouded by prejudice and ignorance.

It is such a landscape that technological changes might normally have been expected to produce. Indeed, it does sometimes emerge initially when a traditional farm is taken over by a more go-ahead farmer. Fairly soon, however, thoughtless acts of destruction unrelated to technical requirements are found to have taken place, and it is then that other questions have to be asked.

This type of behaviour, divorced from rational considerations, is substantially more in evidence in stock farming areas. Here there are very few constraints imposed by machinery. The changes which stem from practical developments relate mainly to food supplements for livestock, open stabling, and machine milking, not to machinery considerations which have a direct bearing on the landscape and impose special constraints. But the practice of grubbing up hedges affects stock farming regions no less than the others. The process of deterioration is sometimes slower, but it is continuous and relentless. A hedge on one side of a field will be removed, sometimes only a few metres of it; then the gap grows larger, soon another hedge is attacked and the hedgerow structure is gradually broken down. The reasons given to justify this destruction are less clear-cut here than in arable areas and have a less sound objective basis.

In fact, the true objective causes of the decline of hedgerows can be fully appreciated only in the major crop growing areas, where attempts must be made to reduce the number of machine turn-rounds, to use the land more efficiently and to provide better access to fields, although this trend towards enlargement must remain below a level where the disadvantages of hedge removal outweigh the advantages of efficient machine working. Our own observations show that this level varies with local conditions and needs to be determined with the assistance of an ecologist, the optimum size often being smaller than that currently adopted in industrial farming.

Negative effects of hedgerows

One of the most frequent criticisms levelled against hedgerows is that they take up land which otherwise might be farmed. There is also the question of the time spent on the upkeep of hedgerows.

Certainly the space covered by banks, rows of trees and low bushes is far from negligible, as may be seen by making a few simple calculations on the basis of square or rectangular hedged fields, which are not the norm but are often to be found in certain types of enclosed agrarian countryside.

In the case of a 4-hectare field (which is not the norm either), 200 metres by 200 metres with hedges 1 metre wide, an area of 800 square metres of ground is taken up by hedging. However, if these calculations are extended to the neighbouring fields, account has to be taken of the protection offered by each hedge to two fields at once, since winds often vary in direction even when there are prevailing winds. Furthermore, where hedges provide other advantages connected with ecological balance, it may be assumed that these will also apply to two fields.

While the proportion of land devoted to the growing of hedges is neither negligible, nor spectacular, the estimation of profits due to hedges requires a detailed consideration of the shapes and kinds of subdivisions of tracts concerned. It is difficult to provide a generalised estimate as each instance needs to be considered on the basis of its own merit. In fact, in the calculation of the overall agronomic balance, the actual magnitudes of surface occupied by a hedge may be of lesser significance than the actual quality of the windbreak and other ecological variables. For example, a very large hedge, effective as a windbreak, undoubtedly compensates for the space it occupies by its positive effects, whereas a smaller hedge containing many gaps, may serve no purpose at all, the area it occupies being wasted.

Depending on the hedgerow structure, the proportion of space occupied by hedges frequently ranges from 1/100th to 1/50th or more. In areas recently planted with hedges in Denmark, the amount of ground occupied by windbreaks amounts to 2.3 per cent of the area they protect. However, this seems to be a misreading of the problem and the value of such figures, to which many people refer, appears limited.

The question hinges on whether the economic cost of hedgerows exceeds the benefit derived from them. The same argument could be applied to roads and lanes since they too take up considerable space and are unproductive and uncultivable, but because they serve an obvious purpose no-one questions them. As long as the value of hedges was obvious to farmers, who for a long time acted as empirical ecologists, there was no problem. But since the sense of natural balance has been lost following the spread in rural areas of techniques and ideas unrelated to ecology, farmers generally are ill-informed and the result of weighing up the pros and cons of hedges is always predjudiced through ignorance of a host of factors.

To these comments on difficulties due to the presence of hedgerows we might add a corollary on "edge losses". Taken overall, these losses appear to vary considerably according to the nature of the activities (crop or stock farming), the lie of the hedges, types of species, micro-climates, soil humidity etc. Although the ground wasted along the edge of hedges may be anything up to several metres wide in the case of crops, it is another matter when it comes to grassland. In periods of drought, green grass, shade and moisture are only to be found alongside hedges, so again one cannot be too dogmatic.

The same sort of qualified answers apply to the excessive humidity for which hedges are held responsible. While it certainly exists in some cases, it is often more than counterbalanced by the quantity of water drawn up by trees and the situation varies considerably according to the retention capacity of the soil, the amount of sunshine the ground receives and so on.

Hedges act as shields against erosion and their value as windbreaks is immense.

Windbreaks may induce spring frosts but this is only true of hedges which are too close textured or else too full of gaps. We shall go into these points in greater detail in the next section.

Attention should be drawn to some drawbacks of a purely biological nature. At the edge of fields lined with hedgerows, damp foliage may cause potato blight *(Phytophtora infestans)*. The same thing happens in market gardens with artichoke blight *(Bremia lactucae)*. On the other hand, the climatic benefits afforded to plants by the existence of windbreaks may prevent a drop in their yield (Jouan and Lemaire, 1970). It has also been shown that the length of time leaf stomata stay open behind windbreaks causes more frequent infiltration by mycelial filaments, carriers of beet cercosporiosis. Some undesirable inmates are also to be found in hedges (which provide abundant food for cockchafers and elaters). However, such cases are usually found in conjunction with intensive farming (market gardening, maize monoculture, large orchards attacked by bullfinches and tits).

Taken overall, these disadvantages encourage a different view on the role of hedges. Real though they are, these various negative aspects only appear in certain well defined circumstances and at varying times; their economic importance is hard to assess, and lastly, their drawbacks are frequently offset by advantages. Consequently, it is possible to obtain less equivocal results only through a wide ranging ecological approach covering a maximum of data and not merely confined to the constraints and inconvenience inherent in hedgerows.

Reduction of wind velocity

Hedges prevent crops from being beaten down and from other types of damage due to wind such as the laceration of leaves or the falling of flowers before they are fertilized. When the air encounters an obstacle in the shape of a row of trees or bushes it strikes the obstacle, rises up, and, under compression and acceleration, passes over the top descending again more or less rapidly to ground level. The considerable variation in the extent of the area protected is due partly to differences in their texture.

In the case of compact hedges, stone walls or very high banks just topped with gorse, the air mass strikes the obstacle very violently but encounters an area behind it in which no incident air flow lower down impedes its rapid descent to ground level. This "air vacuum" effect lessens the distance protected. For maximum efficiency, open textured hedges are therefore advisable, because they filter the air flow, allowing a slower and harmless air stream to pass through, which will counteract the rapid descent of the main current.

There is another vital point to be borne in mind in connection with turbulence. In the case of excessively open texture or large gaps at the foot of trees, strong turbulence is produced and may well cancel out the beneficial effects of the hedge. Many studies have come out in favour of windbreaks presenting a degree of open texture. Results recorded on isovelocity curves show that in the case of solid obstacles, the barrier has a negative effect: the isovelocity curves drop down again to ground level much more quickly. For instance, a wall 2.5 metres high only protects a distance twice its own height, i.e. 5-6 metres. The protection afforded by a moderately open windbreak 10 metres high is as much as 100-200 metres. Behind wooded strips formed by certain types of tall thickets, air masses are totally deflected upwards and the distance protected is 20-30 times the height of the thickets.

For example, in recent work (G Guyot) comparing two communes in Morbihan (St Armel and Sarzeau), in only one of which land consolidation had taken place, it was found that wind velocity in hedgerow landscapes was 30-50 per cent lower than in open country.

Potential evapo-transpiration

The value of a hedge does not lie solely in its mechanical windbreak effect but also in the control of evapo-transpiration, that is the quantity of moisture lost by plants and the soil in which they are growing. As moisture in the soil evaporates in the sun, the leaves also exude vapour into the air through their microscopic orifices, the stomata. The net result of the combination of these two phenomena in the process of evapotranspiration reveals some curious facts.

When plants and soil are exposed to wind, the latter supplies energy, and evapo-transpiration therefore increases. In 1954 Jansen established that plant moisture loss was directly proportional to increase in wind velocity. In order to reduce this loss, the plant closes its stomata. Yet the latter need to be open in order to allow the carbon dioxide involved in the process of photosynthesis to pass through. Photosynthesis, the absorption and conversion of sunlight, lies at the root of productivity. The vegetable matter produced by plants comes from their absorption of solar energy by means of chlorophyl, the green pigment in their leaves. Although the overall efficiency of

CROP	COUNTRY	Increase (% over crops without windbreak)
Sugarbeet	DENMARK 1, 7	23.2
	GERMANY 9, 13	11.4 (root)
		12.3 (sugar)
		6 (root)
		8 (sugar)
Mangelwurzel	USSR 2	21 (root)
	(Rostashi)	27 (leaf)
Winter wheat	USSR 2, 3	15 (grain)
		16 (straw)
		20
Summer wheat	USSR 2	6 (grain)
	(Rostashi)	3 (straw)
	USSR 2, 3	
	(Guselskii)	23
	USSR 4	10
	USSR	21
	(Transvolodie)	
	RUMANIA 5	23
	(Marculesti)	
	RUMANIA 6	20-50
	(Baragan)	
	FRANCE 16	15%
	(Beauce)	(non-irregated field)
		26%
		(irregated field)
	DENMARK 7	11.1 (grain)
		12.6 (straw)
	CANADA 10	27 (year with heavy snowfall)
		24 (year with average snowfall)
	ITALY 12	18
Maize	RUMANIA 5	14-34
	(Marculesti)	
	UNITED STATES 11	19
	(Nebraska)	
Barley	DENMARK 7	18.8 (grain)
		33.1 (straw)
Oats	GERMANY 13	9
	RUMANIA 6	18
	(Baragan)	
	USSR 8	40 (grain)
	(Kamennaya)	16 (straw)
	DENMARK 7	19.5 (grain)
		19.3 (straw)
Grassland	RUMANIA 5	24-67
	(Marculesti)	
	HUNGARY 14	68
Lucern	DENMARK 7, 1	21.5
Grass and clover	DENMARK 7, 1	24.1
Potatoes	DENMARK 1, 7	16.9
		16.5
		8.8 (protection against East winds only)
	GERMANY 8	15.7
Strawberries	DENMARK 17	45.3
Apple trees	DENMARK 7	167
	NETHERLANDS 15	75
	NETHERLANDS 15	121

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The removal of hedgerows often leads to a drop in yields.

the process is slight (one per cent of the solar radiation absorbed), it is fundamental to all farming production. *In bad conditions with intense evapo-transpiration, the best soil with the best fertiliser will yield mediocre results.*

Experiments to measure windbreak effect against yield have been conducted in many parts of the world. Widely differing figures have been obtained but they all suggest that when there is protection, yield is increased. Plastic screens were used in some of the first experiments, but most of the findings relate to areas protected by hedges, rows of trees or belts of woodland. The differences in the figures are due to local variations in climate, relief and pruning techniques, the latter being probably the predominant factor. Here again, we encounter the problem of texture with a higher rate of evapotranspiration behind close textured shelter belts than with screens which allow columns of air to pass through them.

It is therefore possible to define the degree of agronomic value of different types of hedgerow in terms of their texture. Many types of European hedgerow are unsatisfactory (Lower Saxony, Eastern England, Lot-et-Garonne). A small proportion present too solid obstacles (banks in the Léon region of Brittany, low stone walls in Ireland) while hedgerows preserved as good windbreaks are becoming rare (central France, Cornwall).

Most findings suggest that the gain in productivity is between two and four times greater than the loss caused by the presence of the hedge. Tables I-IV show the relative effects on yields for diverse crops due to hedges, and although some fraction of the percentage may be questionable, one clear trend has to be acknowledged: the general increase in yield on sheltered ground is sufficient to warrant the acceptance of some minor disadvantages.

In Mayenne, Fleury and Milleville (INA, 1971) have shown that in fields of suitable width (150-250 metres), hedges have a beneficial effect on yield. Recent results obtained by INRA in the Morbihan (France) have aroused interest in specific cases where evapo-transpiration is not reduced by the presence of hedges. The effect is due in such cases to an increase in the amount of solar energy being collected, this being reflected off the hedge and inducing conditions which encourage evapo-transpiration. What has still to be defined more accurately is the extent to which this effect is felt over the field as a whole. Moreover, if instead of evapo-transpiration one measures evaporation pure and simple (using a Piche evaporimeter), the result is 20-30 per cent less for hedgerow districts than for open fields. The final results under such conditions are however positive, showing (for maize):

- □ a more rapid growth rate over a strip of land 5 metres away from the windbreak and with a width appoximately 7 times the windbreak's height;
- □ a drop in growth rate and yield in the vicinity of hedges;
- □ a 20 per cent increase in grain production for the strip of land with the earliest crop;
- □ a final higher production of dry matter by all other parts of the plant (the ear excluded) for the strip of land with the earliest crop;
- □ a gradual catching up in growth by plants which are backward at the beginning of the growing period. In the case of maize the results become positive for an area exceeding 3-4 hectares.

To sum up:

1. A number of trials show an increase in yield as potential evapo-transpiration decreases.
2. Other surveys demonstrate advantages arising from thermal factors.
3. The fields must be of a certain size for the effects to be evident. The size will depend very much on local conditions and non-bioclimatological factors (erosion, balance of animal life etc.).

Data on yield very soon become tedious but they should nevertheless by widely publicised as it is the cereal producers and farmers in the strict sense, not stockbreeders, who are most inclined to grub out their hedges. In this connection, a very important psychological factor is worth noting: loss due to hedges is easily perceptible, whereas any gain they bring about in production can only be assessed by means of regular bookkeeping and experimentation, not to mention scientific equipment which may be needed to locate the exact cause of the increase in yield. In the normal way, hedge clearance is therefore likely to produce a drop in production by removing the windbreak effect. When this drop occurs, its cause is not recognised and may even be disguised by the massive use of fertilizers.

It is possibly easier to demonstrate the positive effects of hedgerows in stock farming areas because of the obvious sensitivity of animals to weather conditions from the health point of view. Some dairy producers in the Finistère put the difference in the yield of two grasslands with identical soil, but one of which is well sheltered from westerly winds, at 20 per cent (Mazerand, 1960).

Precipitation — temperature

As a shelterbelt intercepts precipitation, the quantity of moisture deposited behind a hedge is less than in an area exposed to wind. However, in the rest of the sheltered area, reduced wind speed is found to produce an increase in the moisture deposited. The difference by comparison with open countryside amounts to 15 per cent on average of the quantity deposited in open fields, giving a very distinct increase in the reserves available in the soil.

The influence of shelterbelts on temperatures is much disputed. Depending on the time of day, a hedge may cause a rise or fall in temperature. Complex factors are involved. Where there is more rapid nocturnal cooling, the fact of the dew forming sooner slows down the cooling process. Although the latter has begun earlier, it is then less extreme than in open country. Moreover, in areas which are often under snow, hedges prevent the wind from blowing away the layer of snow which protects the soil from heavy frosts.

The most recent studies (carried out by the INRA in Morbihan) show that in hedgerow country the maximum daytime temperatures are generally higher (0.5 - 1.5 per cent) whereas the minimum nocturnal temperature can be either lower or higher, 47 per cent of nights having a higher temperature and 53 per cent a lower one. This percentage fluctuates in favour of higher temperature when there is cloud. Where there is a drop in temperature towards the centre of the field, this is always offset by a rise in the immediate vicinity of the hedge (centre = $-0.8°C$, near hedge = $+2°C$).

It might be imagined that mere rows of trees planted at regular intervals facing prevailing winds would be enough for the effects to be the same. Yet in cases where this has been tried out, long-term observation pleads for the modification of this type of structure in favour of a closer resemblance to hedgerow patterns.

In Denmark, the first windbreaks were planted facing north and south, but recent studies have shown that the efficiency of the network was improved by planting secondary shelterbelts at right angles to the main shelterbelts, thereby enclosing the fields. For reasons of texture, deciduous windbreaks are preferred to conifers and bushes are inserted between the trees to prevent turbulence. A gradual diversification of plant species is restoring a hedgerow-like state of balance.

Soils and erosion

Hedges act as a shield against erosion, whether by water or wind. Whenever clearance work has been carried out in connection with land consolidation, the next storm causes arable soil to be swept away in the water flowing down the wide ditches alongside new roads. Several months later, layers of soil several centimeters deep are to be found downstream. All this lost soil has to be made up in fertilisers. As for the phenomenon of "growing pebbles", as it is sometimes picturesquely described, this is simply a product of wind erosion which gradually diminishes the depth of arable soil.

Hedgerows provide a habitat for insect-eating birds — the natural allies of the farmer

The effects on the amount of water available in the soil are complex. Fields on high ground may dry out very noticeably but boggy patches are often to be found in low lying fields (Marion 1958). In hedgerow countryside generally, rainwater sinks into the soil before it has time to run off. Many disused lanes fill up with water and act as catchments and reserves, providing moisture during excessively dry periods.

The excess moisture itself is offset by evaporation of the water drawn up by the trees. There are thus counterbalancing factors which help to mitigate the effects of disequilibria. Flooding is thus less extensive and less destructive. It has taken present day floods due to deforestation to sweep away Roman bridges which have survived until now.

From the point of view of local climate, it is even safe to assume that violent weather conditions such as gales are less frequent and less severe in hedgerow country. According to a survey by the Morbihan Caisse Mutuelle de Réassurance Agricole, 80 per cent of the 4,000 claims received for damage after a storm on February 12th 1970 were recorded in localities where land consolidation and hedge clearance had taken place.

We begin to see what intricate factors are involved. While their assessment is easier and more advanced as far as the windbreak effect is concerned, clearly the latter is also linked with the control of hydrous balance which in turn depends on biological as well as pedological or geomorphological factors. At all events, soil dessication or leaching, erosion by water and, less frequently, by wind cause damage to arable land which is detrimental to productivity.

All these factors are inter-linked. The extension of maize growing, combined with the practice of grubbing out hedges, is considerably increasing the prevalence of this plant, which is known to be extremely conducive to erosion owing to the size of the open spaces between each stalk. What is more, the practice of feeding beef cattle sometimes exclusively on maize silage produces poor quality meat from undernourished animals only surviving through injections of the substances lacking in their feed, unless that is they are slaughtered very young or die from liver diseases caused by their inadequate diet.

However, to return to the question of water, a word must be said about the adverse effects of the reshaping of stream and river beds, drowning fields already saturated because of the removal of hedges halfway up the banks, or else completely draining fields on high ground so that they are deprived of their moisture reserves.

The systematic draining of small marshes and the disappearance of old disused lanes, which stored and balanced the supply of water, exacerbates extreme conditions which are directly prejudicial to farming activities.

Dried up or erratic springs, the difficulty of maintaining certain water sources and the appearance of dessication fissures on clay soil are signs of profound change, and there is reason to fear that the drop in water tables may produce irreversible consequences.

Because of the biological nature of its activities, agriculture depends on such factors. It will never be an industry like any other despite the dreams of some. Just as it has to take account of physical environmental factors, it likewise has to pay heed to the multiple interactions of living creatures, if it is to maintain satisfactory production conditions.

Biological balance

At all levels of the animal kingdom, there are indications that hedgerow country provides an optimal balance between human activities and the natural environment. While the latter can and should be modified for the benefit of humanity, there is a threshold of 'artificialisation' beyond which disasters occur making the initial objectives unattainable.

To illustrate the serious setbacks which inevitably result from any break in the complex ecological chains, let us take the case of birds of prey which are now officially protected against shooting but not against the destruction of their natural habitats. Birds of prey keep down the common vole which is only to be found in devastating numbers in open countryside. But buzzards, sparrow hawks, falcons and the different varieties of owls need refuge: hollow trees, dead tree trunks, quiet and remote clumps of trees. Wherever bulldozers have been at work, the number of these allies of farming falls sharply. Some find refuge in woods, which are theoretically exempt from clearance due to land consolidation. But then there is competition between individual birds over hunting territory, and the general fall-off in their numbers can be measured by the rapid increase in common voles which are steppeland animals and can do without hedgrow cover.

In open field country the lack of ecological balance is evident: one species of vole *(Microtus arvalis)* predominates over all others (66.4 per cent) and is particularly harmful because it feeds on green vegetation (herbage, cereals). Such proliferation does not occur in hedgerow country. A low ratio of insectivores is also noted in open field country. Numerous similar cases could be cited with reference to insectivorous birds, hedgehogs, reptiles, foxes, small carnivores etc.

It is impossible to enumerate the immense range of insectivorous birds — tits, warblers, wheatears, redstarts, nightingales etc. — present in hedgerows, but it is a fact that their disappearance is reflected in the enormous pullulation of entomological fauna. Although the quantity of caterpillars and various larvae consumed may vary, it is always considerable and the trends induced by destroying these birds' habitat are bound to have an adverse economic effect because of the prolific increase in a wide variety of insects (elaters, cockchafers, weevils etc.)

Then the only course left is to resort to pollutant chemical treatment which is often rendered inaffective by the appearance of resistant strains. As birds are the best insecticides we have, hedgerows provide the most suitable biotope for the conservation of these valuable species.

The presence of grain-eating or fruit-eating birds in hedges might swing the balance the other way, but no species exists in isolation and every constant or occasional forager in hedgerow country has its predator counterpart which keeps its numbers in check so that damage is cut down considerably. The opening up of hedgerow countryside, by altering the ratios of predation leads to pululation often by species regarded as harmful which, in many cases, are more capable of adapting themselves to open conditions than their predators. From the point of view of ecological chains, cultivated land is similar to steppe environments and particularly attracts animals used to feeding in this kind of biotope which only occasionally take cover in hedges and can do without them, whereas this is not the case with many of their predator counterparts. This applies particularly to the common vole but generally speaking, the variety of species maintains a balance which, in turn, ensures the absence of damage by crop ravages or at least, minimises them.

There are also interesting avenues to be explored in the world of entomophagous or parasitic insects. Difficulty often arises from ignorance of the feeding habits of certain species and a dearth of information concerning their behaviour and way of life which seriously hamper investigations. Despite the research which still has to be done in this field, however, there is already a great deal of data available which points to the need to preserve hedges and local wasteland.

For instance, the control of aphids is considerably aided by the presence of ladybirds which are their normal predators. The wide-scale breeding of these insects can replace the use of insecticides. Experiments in Poland have recently shown that there is a cause and effect relationship between the number of copses, the number of ladybirds and the decrease in damage caused by aphids (Galacka, 1966). Other studies have shown that aphids are also subject to mass attack from the larvae of Syrphid Diptera and numerous varieties of entomophaga. Other species, such as Robber flies *(Asilidae)*, attack *Tipulidae, Simuliidae* and, again, aphids.

Diptera of the *Tachina* genus control several varieties of *Hymenoptera, Coleoptera* and *Orthoptera*. For instance, *Tachina* flies lay their eggs on prey left by *Hymenoptera* for their larvae. The latter die of starvation, their food supply used up by the dipterous larvae. *Tachina* flies also attack caterpillars on which they are directly parasitic. These interrelationships between species are of agricultural importance in the long run, even when it is only a matter of competition between species which do not seem to have any direct agronomic bearing — one insect controlling another, which preys on another, which in turn keeps down yet another, thus forming a food chain which nearly always includes crop ravagers in the end.

Everything hinges on population control. Even directly beneficial insects serve as host or prey to

THE EFFECTS OF SHELTER ON CROP YIELDS IN DENMARK

Crops	Increased yield with shelter	Crops	Increased yield with shelter
Cereals		Root vegetables	
Rye (3 trials) – grain	+ 14.8%	Beet (6 trials)	+ 23.2%
Rye (3 trails) – straw	+ 10.6%	Turnips (5 trials)	+ 6.5%
Wheat (1 trial) – grain	+ 11.1%	Potatoes (10 trials)	+ 16.5%
		Green Fodder	
Wheat (1 trial) – straw	+ 12.6%	Grass and clover (8 trials)	+ 24.1%
Oats (8 trials) – grain	+ 19.5%	Lucern (1 trial)	+ 21.5%
		Lupin (1 trial)	+ 48.9%
Oats (8 trials) – staw	+ 19.3%		
Barley (1 trial) – grain	+ 18.8%		
Barley (1 trial) – straw	+ 33.1%		

others; a species which is useful because of one facet of its activities might become injurious if allowed to multiply to such an extent that a hitherto secondary aspect of its activities assumed excessive proportions. Thus the only answer is variety — this being inseparably linked with the preservation of plant cover and fundamental control systems which, apart from the groups and species already mentioned, rely essentially on the huge family of parasitic *Hymenoptera*. The varieties of these tiny insects, which are related to wasps, are innumerable. One or another is parasitic upon almost every species of hedge insect and their action is absolutely fundamental to preserving an ecological balance.

In England, Lewis (1968) counted the number of parasitic and predatory species found in hedge bottoms on a windy day and discovered that they accounted for 50 per cent of the species observed.

Hyperparasitism (parasites parasitic upon other parasites) provides a further complication and defies description in full, but at the practical level biological control techniques are making increasing use of these *Hymenoptora* (Ichneumonids, Braconids, Chalcids) which are already present in hedges.

Two Examples of Ecological Balance

Many studies, memoranda and reports concur on the beneficial effects of hedgerows on the balance of flora and fauna, which always has agronomic implications. We shall quote two more examples, although it must be realised that an exhaustive summary of the factors actually involved would take several volumes:

□ Sugar beet is subject to yellowing caused by a virus transmitted by peach-fly *(Mysus persicae)*. This produces a drop in yield of between 5 and 10 per cent. The influence of the wind on the dispersion of aphids by winged carriers is very striking. A comparison between open countryside (Pithiviers: the Beauce region) and the southern Seine-et-Marne, which is more interspersed with woods and thickets, suggests that ecologically balanced soils are better able to withstand invasions of such aphids thanks to both windbreak effect and the presence of numerous predators *(Coccinella septempunctata, Adala bipunctata,* larvae of Hemerobidae and Chrysopa) (Du Retail, 1973).

□ Some considerations concerning ground fauna are also of interest. *Collembola Arthropleona* are a suborder of primitive wingless insects (Apterygota) including numerous varieties which live underground. Their food is a combination of protozoa, pollen and plant waste matter. They play a part in maintaining the balance of bacteria populations. Together with earthworms they aid the assimilation of organic matter in soil substrata. By cutting up the various matter they consume very finely, they also increase comparable activity by bacteria.

Their action is combined with that of *Acaridae Oribatidae* which eat fungi, bacteria and pollen, and of saprophagous Nematoda which feed on protozoa, algae, fungi and diatoms. The number of Nematoda in hedgrow banks and fields is unknown but it seems likely that the figures for certain hedgerow areas might be similar to those obtained by Volz (1951) in the Sénart Forest: 30 million per m^2. A recent hypothesis attributes to various Nematoda the particular function of secreting a special substance with a direct influence on humification processes. The latter, which result from the action of the groups already mentioned, also depend on the action of innumerable thecamoeban protozoa living in very thin films of moisture inside the soil. They reach densities of several hundred million per square metre and have complex feeding habits which appear to consist mainly of preying on bacteria. They form a line in the ecological chain in both cultivated and uncultivated ground. However, many *Collembola, Oribatidae, Nematoda and Thecamoebae* are extremely sensitive to soil desiccation. Following hedge clearance the increase in evaporation in many fields and pronounced desiccation in clay soils are liable to cause falls in population densities, thereby upsetting the balance of soil life which is essential to good production conditions.

Such data does not of course provide the full picture, but the fact that they are just samples of innumerable instances cited in literature on the subject is enough to cause grave anxiety concerning the effects on agriculture of the clearance of thickets, the eradication of wastelands and the grubbing out of hedges.

The arguments in favour of hedgerows are still more overwhelming if domesticated livestock are included in the ecosystems. According to many veterinary surgeons, the disappearance of hedges in stockfarming areas has caused an increase in bovine tuberculosis and bronchitis, as well as a rise in mortality due to sunstroke in summer. Some report an extension of grassland tetany and brucellosis coinciding with the disappearance of hedgerows. While the causes of these outbreaks are not always clear — particularly in the case of tetany — the existence of hedges seems to be essential to break the cycle of parasitic diseases.

Indirect effects are also making themselves felt. The removal of hedgerows often results in a radical change in the nature of production techniques: heavy equipment compressing the soil and mono-cultures, such as maize, encouraging erosion and the spread of disease, parasitosis and the increase of crop predators.

Conclusion — Need for a New Economic Approach

From the strictly agricultural point of view, we have been able to show:

1. Some drawbacks resulting in a loss in productivity.

2. Many advantages whose combined weight cancels out and exceeds any losses recorded. Some of these advantages are readily calculable (wind), others less so (erosion) and still others not at all (biological balance). However, in the case of non-calculable factors, discernible trends are emerging.
3. The relatively modest cost of upkeep.

It would be unscientific to take account of calculable factors only. However, in our opinion, they alone are sufficient to tip the scales in favour of hedgerows. Even if some of the explanations are open to qualification, the effects on yield are clearly positive in a great many cases.

Nevertheless, the non-calculable factors serve a particularly useful purpose. Even if it cannot be measured, an evolutionary trend still plays a determining role in reality. The positive or negative direction of changes in a particular ecosystem may make it possible to foresee future imbalances, even if it is more a matter of approximate assessment then accurate quantification.

When the explanatory theories for trends are controversial, the best practical policy is to observe results in the field. Having established a comprehensive viewpoint through our own observations combined with those of numerous research workers, we feel the need for a revision of traditional methods of economic assessment. Reducing the multiple data revealed by any analysis of biological productivity to measurable factors alone results in a short-sighted assessment which may lead planning schemes badly astray. A new economic approach is needed to all activities which impinge on ecological chains. It will take account not only of figures but of converging patterns of evolutionary trends as well as non-material assets (space, nature of the environment, life-style etc). The role of the ecologist in a planning scheme is similar to that of the doctor. Unquantifiable symptoms may be signs of serious disorders. The symptoms currently appearing as a result of the alteration of European agrarian landscapes are sufficiently clear-cut for the conservation of hedgerows to be deemed a necessity.

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NB These are but a few of the works most directly concerned with the agronomic and ecological problems of hedgerows.

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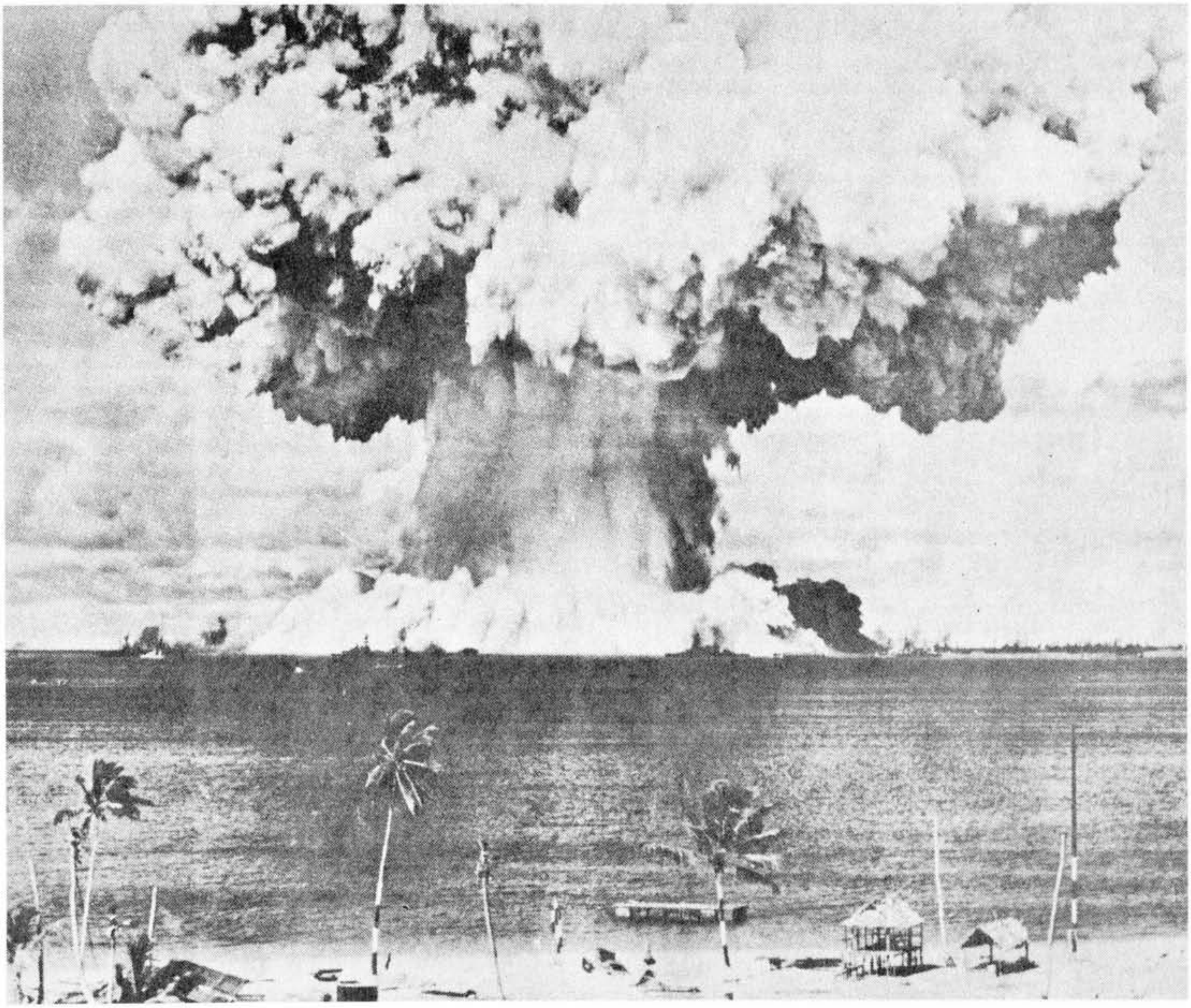

A Tale of Two Islands: Bikini and Enewetak

by
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Last year, the inhabitants of Enewetak, a former nuclear test site in the Marshall Islands, returned home. They had been in exile for thirty-three years. Will their resettlement prove as catastrophic as that of the Bikini islanders?

There is a traditional folk legend in the Marshall Islands about Etao, the mischievous spirit who was half-human and half-god. Etao — whose name in Marshallese is synonymous with slyness — was known to play mean tricks on people and then laugh at them; when something untoward happened people used to say that Etao was behind it. After sixty-six nuclear weapons tests and many gross violations of its United Nations trust agreement, the United States is seen by the Marshall Islanders as the latter-day Etao.

Last year the US Government performed an alchemy trick in the Marshalls, but instead of transmuting base metal into gold, it concluded the largest radiological cleanup and rehabilitation project in history at Enewetak. Five hundred and fifty of the original inhabitants of Enewetak, a former nuclear test site, returned home after their 33-year forced exile to an inhospitable and previously uninhabited atoll. The resettlement project and desire of the Enewetak islanders to return home has caused much infighting between various US agencies. Radiation experts are uncertain about the potential health risks associated with the return to a still-radioactive environment where the people are expected to adhere to a concocted living pattern very different from that of their neighbours on other atolls. The catastrophic resettlement failure a few years ago at Bikini, another test site, looms ominously in the background of the present resettlement programme.

The newly-elected Government of the Marshall Islands, not forgetting the awesome lesson learned at Bikini, has cautioned the Enewetak islanders about the need for further study of their atoll by independent radiation scientists outside of the US Government. In response to the Marshall Government's perceived interference with the resettlement, some Enewetak islanders have recently announced their plan to *separate* from the Marshalls at hearings before the US Congress and at the Trusteeship Council of the U.N.

The Marshall Islands

The Marshalls comprise the easternmost group in the Trust Territory of the Pacific Islands, commonly known as Micronesia. The Territory covers an expanse of the North Pacific Ocean larger than the continental US, yet the 2,000 islands (of which only 100 are inhabited) make up a land mass of 700 square miles — roughly one-half the size of Rhode Island. The high volcanic islands and low-lying coral atolls are believed to have been settled around 1,000 B.C. (the Marshalls were settled much later — perhaps 600 years ago) by a mixture of Caucasoid-Mongoloid peoples originating from Indonesia and Melanesia. The 125,000 Micronesians speak nine major languages which, while sharing a common root in the Austronesian linguistic family, are mutually unintelligible.

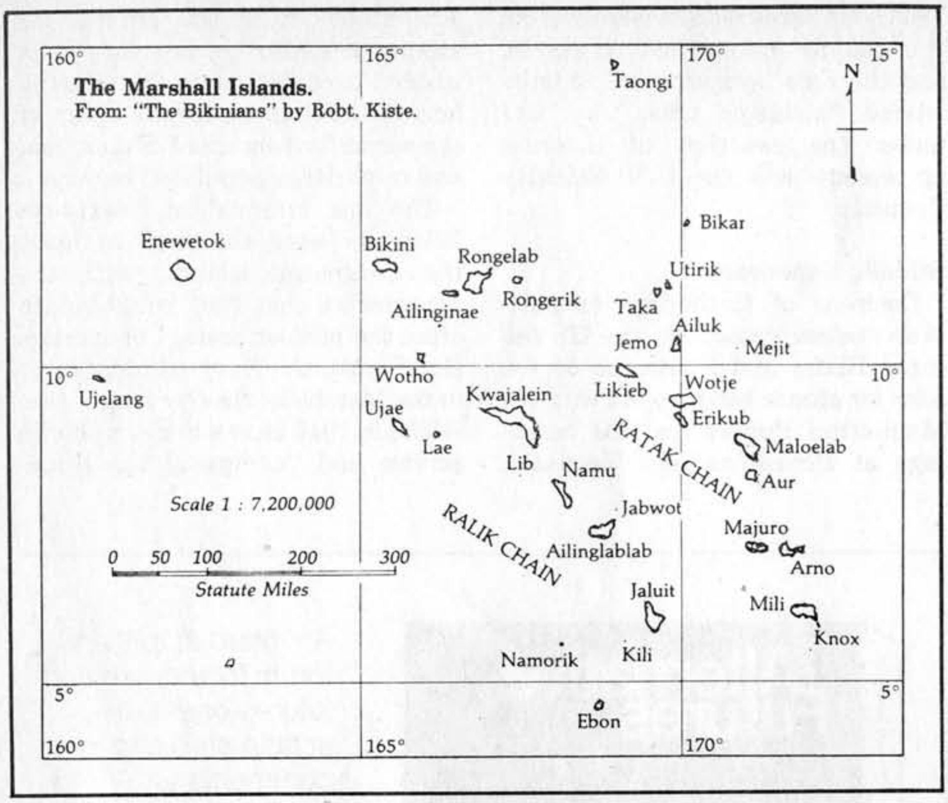
Foreign contact in the Marshalls (population: 30,000) was first felt when German whalers, blackbirders, and missionaries made regular visits beginning in the mid-1800's. The traditional spiritual beliefs were supplanted by Christianity and the islanders were coerced from a fishing and subsistence way of life into that of a cash economy with the production for sale of copra-dried coconut meat.

The Japanese followed the Germans in the early 20th century and viewed the islands as future settlements to relieve swelling population pressures at home. When the invading US forces landed in 1944, they wrestled the islands from the heavily entrenched Japanese, and the area became a US administered "strategic trust" in 1947 under the sanction of a trust agreement with the U.N. Security Council.

Bikini's Experience

Desirous of furthering its post-War nuclear monopoly, the US selected Bikini and Enewetak as the sites for atomic tests, begun with the Manhattan Project and the bombings at Hiroshima and Nagasaki. The atolls fitted the criteria for atomic test sites because they were under US control and offered excellent facilities in an isolated part of the world far from the US mainland and other large populated regions.

The one hundred and sixty-six Bikinians were the first to leave their ancestral islands, with the reassurance that they could return after the nuclear tests. Commodore Ben Wyatt, the Navy administrator in the Marshalls, flew by seaplane to Bikini in 1946 after a Sunday church service and "compared the Bikin-



The Marshall Islands.
From: "The Bikinians" by Robt. Kiste.

ians with the children of Israel whom the Lord saved from their enemy and led into the Promised Land."[1] Wyatt described the power of the atomic bomb to the Bikini people and explained that American scientists "are trying to learn how to use it for the good of mankind and to end all world wars."[2] The Bikinians, after seeing the US crush the powerful, long-term Japanese administrators in their islands, reluctantly consented and were taken to the uninhabited atoll of Rongerik. Far from being the "Promised Land," Rongerik was less than one-quarter the size of Bikini; within that year the people began to suffer from malnutrition because of the inability of the local foods to sustain a permanent population. Across the way, "Operation Crossroads" commenced on Bikini with the explosion of two atomic bombs in a military and scientific exercise employing 42,000 personnel, 250 ships and 150 aircraft.

Operation Sandstone

In 1947 President Truman approved "Operation Sandstone," a series of tests intended to develop a new hybrid of nuclear weapons. Enewetak, being much larger than Bikini, was chosen for Sandstone, and like their neighbours before them, the Enewetak islanders were asked to sacrifice their atoll for the testing of a new generation of nuclear weapons. In December 1947, the Enewetak people were taken to Ujelang, an isolated and rat-infested uninhabited atoll less than a quarter the size of Enewetak. The rats were so numerous and troublesome that the Enewetak people frequently had to sleep inside wooden boxes in order to discourage the pests.

The move to Ujelang was complicated by the fact that Enewetak was made up of two distinct island groups — the dri-Enewetak and the dri-Enjebi — who inhabited the two large respective islands in the atoll complex. The dri-Enewetak in the southern portion of the atoll had been traditionally separated from their counterparts in the northern part of the atoll and each group had its own set of traditional sub-chiefs. The entire social fabric of Enewetak, intimately linked with ancestral and usufruct rights to scarce land, as in the rest of the Marshalls, was thrown into chaos when the two groups were forced to live together on the one small main island at Ujelang. Like the Bikinians, the people of Enewetak believed they could return home soon and viewed the move as a temporary one. Ironically, at this same time the US was signing the U.N. trust agreement which pledged the US to "protect the inhabitants against the loss of their lands and resources," and also to "protect the health of the inhabitants."

Meanwhile, the starving Bikini islanders at Rongerik were once again moved — as in the game of "musical chairs" — to Kili Island far to the south. Kili, being a single island without a fringing reef or lagoon, was a formidable challenge for the Bikinians. Like other Marshallese, the Bikini people relied upon their centuries-old fishing skills in protected lagoons for their protein supply. With the full force of the Pacific crashing in all around them at Kili, the Bikinians were ill-adapted for their new hardships and became the first welfare population in the Marshalls to rely solely upon imports of US Department of Agriculture food.

Fall-Out from the Tests

In 1952 the first hydrogen bomb was exploded during "Operation Ivy" at Enewetak. Code-named "Mike," the 10.4-megaton bomb yield (750 times more powerful than the Hiroshima blast) vaporized one island and sent a 100-foot tidal wave awash over Enjebi Island adjacent to the test site. Two years later, "Bravo," the second and largest hydrogen bomb ever exploded by the US, produced a 15-megaton yield which sent a radioactive cloud twenty-two miles into the stratosphere high above Bikini. The populated atolls of Rongelap and Utirik were caught in the dangerous fallout carried by "unexpected wind shifts":[3] after 27 years the pernicious long-term effects of radiation disease — including cancer and genetic damage — *have not yet reached a peak.* In all, the US exploded twenty-three weapons at Bikini and forty-three at Enewetak at a cost of $20 billion between 1946 and 1958, when the US agreed to halt atmospheric testing prior to the 1962 Limited Test Ban Treaty.

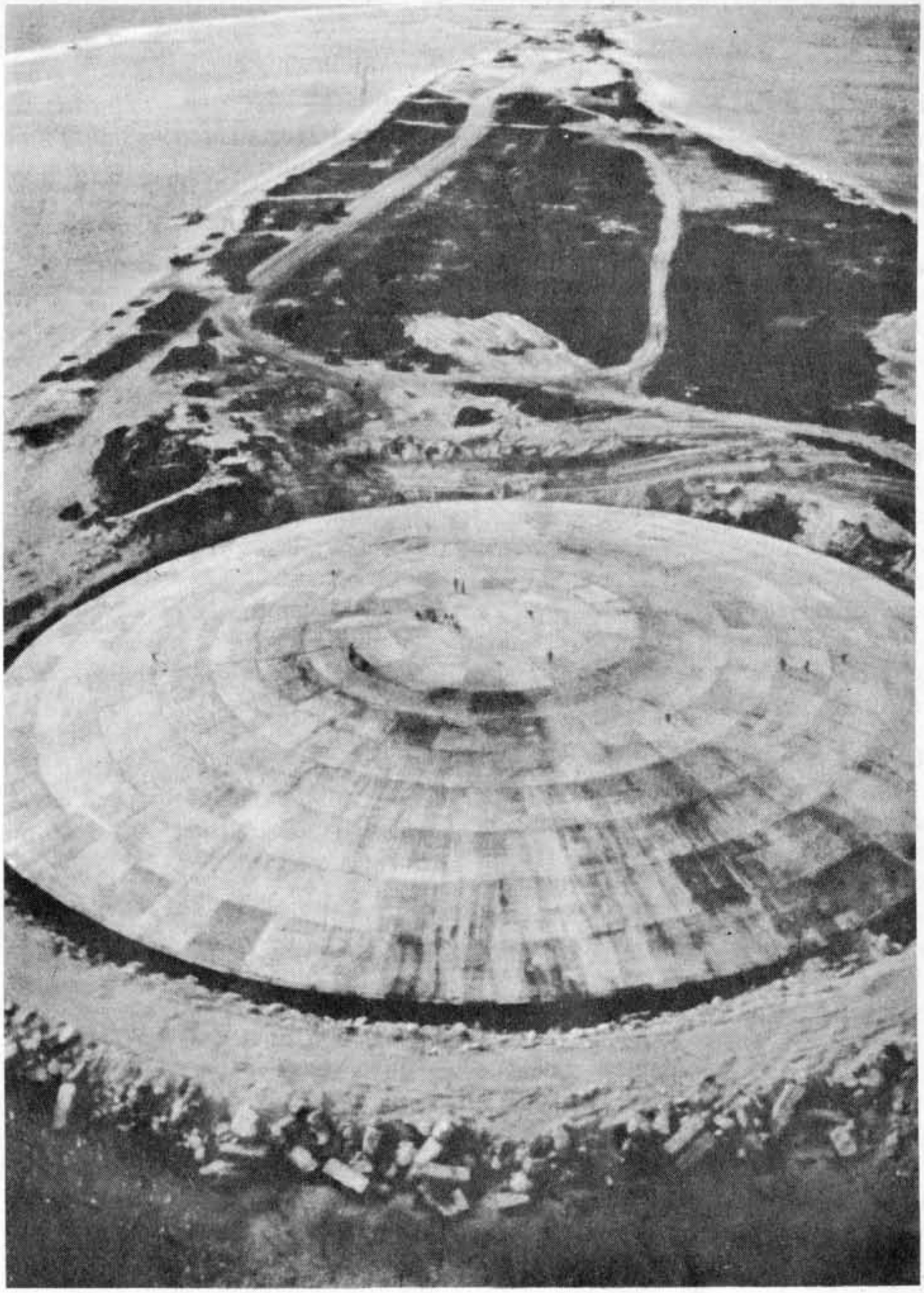
The Return of the Natives

In fulfillment of an earlier promise, President Johnson declared in 1968 that Bikini could be returned to its former residents at the conclusion of a radiological cleanup and rehabilitation programme. During the next several years radioactive topsoil was bulldozed at Bikini and 87,000 coconut seedlings were planted after the former vegetation —what was left of it — had been cleared away. The Atomic Energy Commission (AEC) determined in 1969 that Bikini was safe for habitation, but admitted that they could not possibly return the atoll to its former state. Instead, the AEC attempted to reduce radiation to an "acceptable" level, and the newly-constructed village houses were built with thick cement floors to help minimize exposure from residual radiation still lingering on Bikini. In addition, the AEC did a study of Marshallese dietary patterns and concluded that per capita coconut intake was nine grams daily. Coconuts were known to concentrate high levels of radionuclides (e.g. strontium-90 and cesium-137), and accordingly, the AEC prescribed a restrictive diet consisting of no more than nine grams of coconut daily.[4] Along with other dietary restrictions, the proposed Bikini diet was to be supplemented in large part with imported USDA foods. Eager to return home after their long exile, many Bikinians accepted the terms of their resettlement and moved back to their ancestral atoll.

On Ujelang, the ex-Enewetak islanders learned of the Bikini return and began pressing for a similar cleanup of their former atoll. With the help of Micronesian Legal Services (MLS) — a US Government-funded law group — the Enewetakese pressured Congress to conduct a preliminary radiological assessment for a prospective return. When MLS lawyers in 1974 sought the advice of Edward Martell, a noted radiation scientist involved with the 1950's weapons tests at Enewetak, he warned of the dangers involved with resettlement. With regard to the proposed cleanup at Enewetak, Martell said:

> "The resettlement of such sites is extremely likely to have tragic consequences, particularly for the younger members of the inhabitants. Progressively worse consequences are to be expected for each successive generation in the affected group."[5]

Disregarding the advice of Martell, MLS lawyers pushed for the cleanup and the Enewetak project went forward.



The crater from the 'Cactus' atomic bomb, exploded on Runit Island. 110,000 cubic yards of radioactive topsoil were dumped in the crater which has now been sealed off. The crater has been declared 'off-limits' for the next 24,000 years.

The Rehabilitation Programme

When Congress appropriated the initial $20 million in 1976, the Defense Nuclear Agency (DNA) of the Defense Department was given the authority to coordinate the cleanup between various US agencies. The Department of Energy (DOE), which superceded the defunct AEC, had the task of monitoring radiation levels throughout the operation, and the Department of the Interior (DOI) supervised village construction for the rehabilitation part of the programme.

A 1974 AEC radiological survey revealed that two distinct types of soil contamination were present at Enewetak, "transuranics" and "suburanics."[6] Transuranics are elements above uranium in the atomic table and typically have very long half-lives, such as 24,000 years for plutonium. Suburanics below uranium, such as strontium with a half-life of 28 years, are shorter lived. Plutonium and americium, the two principal transuranics at Enewetak, were concentrated in the top few centimeters of soil. Because of their water solubility, the two main suburanics of cesium-137 and strontium-90 were found at much deeper depths at Enewetak. For this reason DNA focused on the transuranics with the understanding that the suburanics would decay to an "acceptable" level within a relatively short period. The DNA sought to remove radioactive topsoil from the southern islands only; only as an afterthought did they attempt to clean up the northern islands.

Runit Island, in the center of the atoll, was chosen as the site to entomb the topsoil. Into the "Cactus" atomic bomb crater, 110,000 cubic yards of radioactive topsoil were mixed with cement into a "slurry" and then covered with a concrete seal. Runit, with its colossal 300-foot dome, was then declared off-limits for 24,000 years.

Human Experimentation?

Back on Bikini, DOE medical surveys continued to monitor radiation levels of the returning islanders. Traces of radionuclides were detected in the population, and in 1976 a scientist from Lawrence Livermore Laboratory in California stated that Bikini

> ". . . is possibly the best available source of data for evaluating the transfer of plutonium across the gut wall after being incorporated into biological systems."[7]

By 1978 it was learned that the Bikinians — *who were formerly unexposed* — had ingested the largest amount of radiation of any human group in the world. The earlier AEC study of Marshallese dietary patterns which assumed a per capita coconut consumption of nine grams daily had grossly underestimated the actual Marshallese diet of between five to ten coconuts daily. Caught in an embarrassing situation, the DOI (which administers all of the Trust Territory) quickly evacuated the people and the 144 Bikinians returned to Kili, which they now referred to as the "prison". Their patience exhausted, the Bikini people have now filed a $400 million lawsuit against the US for land damages: according to a recent independent radiological assessment the islanders will be unable to return home until the year 2040.

The 'Experts' have their say

Meanwhile, MLS lawyers, representing the Enewetakese, commissioned radiation experts to conduct a risk assessment of Enewetak and Enjebi Island prior to the islanders' return last year. Drs. Michael Bender and A. Bertrand Brill — both of whom are employed by DOE-funded Brookhaven National Laboratory — concluded that the risks facing the islanders were "comparable to those experienced by many other populations elsewhere."[8] This conclusion was reached on the condition that the returning islanders adhere to a restrictive diet with 60 per cent imported foods as well as other artificial living patterns.

Radiation experts outside of the US Government have sharply criticised the Bender-Brill study. In reviewing the study, Dr. Rosalie Bertell — a noted biostatistician and consultant for the New York State and Wisconsin Medical Associations — said:

> "The authors 'reduced' the radiation dose of the inhabitants of Enjebi by averaging in the population less exposed. This is like telling one member of a family his or her risk of lung cancer is lowered if the other non-smoking members of the family are included and an 'average' risk given. It is a scientifically ridiculous approach to public health."[9]

To make matters worse, a 1979 US General Accounting Office report on Enewetak expressed grave concern about the cleanup.[10] The GAO report — which was suspiciously withheld from the Government of the Marshall Islands during post-trusteeship talks with the US — questioned the objectivity of having the Defense Department and the Department of Energy assess its own radiological data from Enewetak. Recommending that Enjebi Island should not be resettled, the GAO report stressed the need for a truly independent radiological survey of Enewetak against the claims by the DOD and the DOE that an independent survey would be redundant.

When I spoke with Lt. Col. Jerry Solinger of DNA about the entombed crater at Runit, he stated that a study by the National Academy of Sciences to assess possible leakage of the crater was not yet available. Solinger did concede that "There is *communication* between the crater and the lagoon," and explained that "leakage would be negligible compared with the radioactivity already in the lagoon from the 43 tests at Enewetak."

John DeYoung — an anthropologist by training — from the Territorial Affairs Office of the Interior Department told me recently that "It is unrealistic to expect artificial living conditions, i.e. the restricted diet and living patterns, to be adhered to for 30 years." DeYoung confirmed the report that of approximately 550 people who had returned to Enewetak last year, about 90 have gone back to Ujelang. "The coconut trees are only three feet high and there is no place to get out of the hot sun," DeYoung said.

According to DeYoung, former Interior Secretary Cecil Andrus rejected Micronesian Legal Services' request for Enjebi to be resettled: Andrus prudently reasoned that "the risks of resettlement outweighed the benefits."

It has been learned recently that a House of Representatives Appropriations sub-committee has rejected the bid to allocate funds to re-build the village at Enjebi Island against the lobbying efforts of Micronesian Legal Services. Albeit for the wrong reasons, this is the only positive thing to come out of the new Administration's budget cuts as far as I can see.

The question for the people of Enewetak is whether they should reinhabit former nuclear test sites where they will be constantly exposed to low-level radiation. The islanders' wish to return home after a forced exile of 33 years is certainly a large factor in the debate; what is not so certain is whether the islanders themselves *truly* understand the inherent dangers — both to their health and to the health of future generations — involved with their return. The DOE and DOD seem bent on using the Enewetak islanders to downplay the long-term effects of low-level radiation, and the Enewetak resettlement presents a microcosmic view of the larger debate about "acceptable" levels of radiation for human populations.

The Poison will not go away

While on a research fieldtrip recently in the Marshalls, I spoke with John Anjain who was magistrate of Rongelap when the radioactive cloud from "Bravo" passed over his atoll in 1954. John, whose son Lekoj died of leukemia several years after the fallout and who himself has had his thyroid gland removed due to the latent effects of radiation, told me:

> "I am afraid to go back to Rongelap because the 'poison' will not go away, like in Enewetak and Bikini, and the number of thyroid operations will only increase in the future. The people of Enewetak are making a big mistake by going back there and the US should not permit it."[11]

Like the evil tricks played by Etao, the US has just financed a $105 million radiological experiment at Enewetak, where we can expect many cases of cancer, genetic damage, and further cultural destruction in the years to come.

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Superscience — Its Mythology and Legitimisation

by Edward Goldsmith

A new breed of scientist sees no contradiction between 'solving' our present ecological crisis and calling for the development of such superstar technologies as fusion and genetic engineering. But, whilst intellectually elegant, the theory underpinning their Brave New World is sadly lacking.

Erich Jantsch was a philosopher and visionary. Sadly, he died last year in his early fifties. *The Self-Organizing Universe** was his last book. In it he refined the ideas already eloquently expressed in a large number of articles and in particular in his previous book *Design for Evolution*** and indeed brought them to their logical conclusion.

This book is dedicated to Ilya Prigogine, the "catalyst of the self-organization paradigm"; rightly so, since Jantsch's philosophy is above all an extension of Prigogine's ideas and it is only in the context of these ideas that it can really be understood.

For this reason I shall consider Prigogine's philosophy first and foremost and indicate when necessary how Jantsch interprets it and seeks further to elaborate it.

Ilya Prigogine is probably the most influential intellectual figure in the French speaking world today. Such eminent intellectual figures as Edgar Morin, Henri Atlan, Jacques Robin and even the brilliant economist René Passet have accepted his theories almost in their entirety. There are a few dissenting voices — that of Danchon[1], for instance, who has bitterly attacked Prigogine's ideas in a letter to *La Recherche* and also René Thom[2] who has done so in a letter to *Le Débat.* What is certain is that Prigogine's ideas, though not essentially new, are formulated in an original way. They fit in together extremely well, and what is more, they provide a coherent and all-embracing paradigm or world-view.

One of the things we know about such structures of beliefs is that, above all, they provide a means of rationalising — and hence of legitimising — a particular policy or way of life. In this respect they fulfil the same function as the mythology developed by a tribal society to rationalise — and hence to legitimise — its particular social behavour pattern.

I think this is clear to the more thoughtful philosophers of science. It is certainly clear to Michael Polanyi[3] who explicitly compared a scientific paradigm to the mythology of a tribal society (The Azande). It is also clear to Monod[4] who prefers the term 'metaphysical epistemology' to paradigm or worldview. "De Platon à Whitehead, de d'Heraclite à Hégel et Marx" he writes "il est évident que ces épistemologies métaphysiques ont toujours été intimement associées aux idées morales et politiques de leurs auteurs. Ces édifices idéologiques, présentés comme *a priori,* étaient en réalité des constructions *a posteriori,* destinées à justifier un thème éthico-politique préconcu."

It is easy to see that this is true of the various paradigms that most shape our thoughts today. Keynsian economics, for instance, is above all a means of rationalising a specific strategy for dealing with unemployment, that which consists in financing new jobs by increasing government expenditure, a strategy that was applied by Roosevelt in his New Deal — long before the appearance of Keynes' *General Theory.*

Adam Smith's *Wealth of Nations,* by showing that it is by behaving in the most egoistic way possible that man can not only best serve his own material interests but also those of society at large, provided a means of rationalising the individualism and egoism that inevitably prevailed with the breakdown of society that accompanied the industrial revolution.

This same fatal trend was further legitimised — somewhat differently — by Freud. His paradigm for explaining pathological human behaviour took the already almost defunct family and community to be the source of all our repressions and frustrations, which he assured us could only be eliminated by still further atomising our society.

This being so, it seems perfectly legitimate to ask what is the social behaviour pattern that Prigogine's paradigm is designed to rationalise and hence legitimise.

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* *The Self-Organizing Universe,* Erich Jantsch. Pergamon Press, Oxford 1980.

** *Design for Evolution,* George Brazillier, New York 1975.

Our Priorities

Particularly revealing on this score is Prigogine's interview with Michel Salomon which appeared in *Prospective et Santé*[5]. From it we learn, among other things, that he is not the least concerned about what must be one of the most frightening features of the world we live in; the population explosion. "I don't see why a population increase per se should be a negative phenomenon" he says. "On the contrary, I regard it as a positive phenomenon. The interaction between men has always generated ideas and development."

It is difficult to believe that the "ideas and development" that this interaction is likely to generate in the next decades will provide much solace to the 1,000 million or so people (a quarter of the world's population) who are expected, by serious students of these problems,[6] to die of starvation during this period.

If Prigogine does not regard feeding the world in the next decades as a problem, it is, he tells Salomon, because he has just returned from China, "and in that immense country only twenty per cent of the land is used for agriculture". He does not realise of course that by world standards, this is a lot. The total terrestrial surface of this globe is approximately 13 billion hectares and only 1.3 billion hectares (i.e. 10 per cent) are used for agricultural purposes, while little more useful land, as FAO has itself admitted, remains to be put under the plough. The outlook is in fact grimmer in China, where every inch of cultivable land is already meticulously and painstakingly cultivated.

Prigogine also assures us that in the USSR, there remain vast areas of desert which could be restored to agricultural use. This too is a vain hope, as the rate at which deserts are being brought back to agricultural use is considerably lower than that at which they are being created — an estimated 50,000 square kilometres per year.

Still more revealing are the goals that, according to him, we must achieve if we are to solve the problems that confront us today. The first is thermo-nuclear fusion. This implies that he sees increased energy use, and hence the new technologies that it can power, as the principal means of solving the problems that confront us today. These problems, as readers of *The Ecologist* well know, are due to the breakdown of natural systems under the impact of technology and industry — and new technologies, rather than restore the proper functioning of these systems, can do no more than assure their further disintegration. What is more, even Abelson, that technomaniac editor of the journal *Science,* admits that the cost of commercial fusion reactors (assuming them to be technically feasible) will be four or five times higher than that of normal fission reactors, which are already so much beyond our means that since 1973, in the USA, the richest country in the world, more than two hundred orders have had to be cancelled.

Our next priority according to Prigogine is to understand climate, presumably so as to modify it to suit our short-term needs. This is also unrealistic. It has taken thousands of millions of years to develop a relatively stable and predictable climate so that, among other things, farmers know when to sow and when to reap. World climate is undoubtedly already changing under the impact of our industrial enterprises, and, to set about changing it purposefully, can only further destabilise it.

Next, he tells us, we must understand how deserts are created — a very laudable aim but one that has already, to all practical purposes, been achieved since we know quite enough about the creation of deserts to avoid creating them and enough, too, to realise that it is logistically and financially impossible to restore them, on any scale, once they have been created.

Our next priority, according to Prigogine, is the development of genetic engineering — that ultimate anti-evolutionary enterprise which all thinking people know can only lead to the annihiliation of whole populations of human and non-human animals, but which the cynical might well hail as the only really effective strategy devised so far by our industrial society for controlling its exploding population.

Our final goal, according to Prigogine, is the creation of colonies in space which, he tells us, should not be all that difficult as there must be many planets in other solar systems that are habitable by man. Of course the idea of supporting whole populations on artificial planets in other solar systems (to which the very basic necessities of life, such as oxygen to breathe, water to drink and food to eat, must be transported from our planet) is quite preposterous. Today we cannot afford to keep more than a small minority of people in a style that they consider is their due *on our own planet* where the conditions required to sustain them are readily available.

It should be clear then, at least to readers of *The Ecologist,*[7] that Prigogine is but another victim of the Great Misinterpretation. Rather than see the terrible problems that confront our society today as the symptoms of the breakdown of natural systems — biological organisms, societies and ecosystems — under the impact of 'development' (and its latest phase industrialisation), he sees them as the symptoms of under-development and under-industrialisation — and proposes, as the only means of solving them, the acceleration and elaboration, particularly in the field of genetic engineering, of the very processes that have brought these problems into being.

It is the impending Biotechnic Revolution, as we shall see, that he regards today as having the most to contribute to our prosperity and welfare, and he is not alone in believing this. Many scientists regard this field as offering limitless possibilities. After all, microorganisms are not in finite supply as are the resources entering into the industrial processes of today. Nor is there any limit to the range of goods and services which, by tinkering with their genes, they can be programmed to provide. Nor does this novel production process give rise to the sort of chemical pollution that our biosphere is ever less capable of absorbing.

It is largely to rationalise and hence legitimise these beliefs that Prigogine has built up his paradigm, his 'metaphysical epistemology' or 'mythology' depending on how one prefers to regard it.

Prigogine's Paradigm

What then are the main features of this paradigm? First of all, and very much to his credit, Prigogine accepts, contrary to Georgescu Roegen and Rifkin, that classical thermodynamics do not apply to the world of living things. The biosphere is simply too sophisticated to be the product of the process of global decline which the entropy law tells us we have been experiencing since the beginning of time.[8] "Even in the simplest cells" he writes "the metabolic function includes several thousand coupled chemical reactions and, as a consequence, requires a delicate mechanism for their coordination and regulation. In other words, we need an extremely sophisticated functional organisation. Furthermore, the metabolic reactions require specific catalysts, the enzymes, which are large molecules possessing a spatial organization, and the organism must be capable of synthesising these substances . . . Each enzyme, or catalyst, performs a complex sequence of operations, we find that it is organised along exactly the same lines as a modern assembly line . . . Such an organization is quite clearly not the result of an evolution toward molecular disorder."

Since he has accepted this, one would have expected him to forget about thermodynamics and set about explaining the behaviour of the world of living things in terms of a different set of laws — those, for instance, that govern the behaviour of biological, social and ecological systems. But Prigogine is very much an Aristo-scientist; for him Science is essentially Physics and it is in terms of this master discipline that the world should be explained. More important, were he to look at the world in terms of basic biological, social and ecological concepts, it would no longer be possible to maintain the credibility of his thesis.

Having found that classical thermodynamics was irrelevant, Prigogine developed his 'non-linear thermodynamics' that was designed to apply precisely to those conditions to which classical thermodynamics (and, in particular, the entropy law) did not apply. It is for this achievement that Prigogine earned his Nobel Prize.

Classical thermodynamics tells us that the dissipation of the sun's energy on our planet can only give rise to entropy which is wrongly identified with biospheric disorder.[7] Non-linear thermodynamics tells us that this need not be so. In certain conditions, the dissipation of the sun's energy on our planet can give rise to two different types of organisation. The first, Prigogine refers to as a 'non-equilibrium stationary state.' The systems that fall into this category are referred to by Jantsch as "static or dynamic steady-state equilibrium systems." Such systems are "structure preserving", in other words they do not change.

Jantsch[9] regards the solar system and its rotating planets as providing examples of such a structure. Prigogine[8] cites a crystal. These structures display 'order' of a type that can apparently be explained on the basis of Boltzman's Ordering Principle. This is a means of determining statistically[8] "the structure of the equilibrium states" or rather the distribution of molecules in the various energy states of a system (he is not referring to living systems but to gases and such-like). The formula is Pi - e - Ei/kT, where Pi = the probability, Ei the energy at the chosen level, k Boltzman's famous constant, and T the temperature.

If one knows the value of Boltzman's constant k, the temperature T and the energy Ei of the chosen level (assuming the system to have three energy levels) then Boltzman's formula tells us that, at a low temperature, nearly all the molecules will be in the lowest energy state. At a high temperature, however, the three probabilities become roughly equal, which means that there are about the same number of molecules in each of the energy states.

In certain conditions, however, the dissipation of the sun's energy gives rise to structures of quite a different type, which Prigogine refers to as 'dissipative structures' and whose occurrence is apparently unpredictable on the basis of Boltzman's Ordering Principle. These, as Prigogine shows, are governed instead by a totally different ordering principle which Prigogine refers to as *order through fluctuations* .

This works in the following way. One starts off with an initial state of randomness or 'homogeneity'. This homogeneity is affected by fluctuations. Rather than being controlled or 'damped', as fluctuations tend to be in stable systems, they are on the contrary 'amplified' and it is this amplification that gives rise to the dissipative structures.

Let us look at some examples of dissipative structures. Jantsch[9] describes the Belousov-Zhabotinsky reaction discovered in 1958. Apparently, if bromate is introduced into a sulphuric acid solution in which malonic acid as well as cerium, iron or manganese ions are present, then the malonic acid will oxidise. If other conditions are satisfied (though Jantsch does not specify what these are) "concentric or rotating spiral waves may be observed which lead to interference patterns. In this and similar reaction systems, pulsations of great regularity may be observed which may last for many hours."

A second example is that of the Benard convection, a sort of whirlpool which is constantly quoted by Prigogine[8] and his disciples. This is how Prigogine describes it: "Consider a horizontal layer of fluid between two infinite parallel planes in a constant gravitational field and let us maintain the lower boundary at temperature Ti and the higher boundary at temperature T2 with Ti = T2. For a sufficiently large value of the 'adverse' gradient (Ti-T2) (T1+T2), the state of rest becomes unstable and convection starts. Entropy production is then increased because the convection is a new mechanism for heat transport. Moreover, the motions of the currents that appear after convection has been established are more highly organised than are the microscopic motions in the state of rest. In fact, large numbers of molecules must move in a coherent fashion over observable distances for a sufficiently long time for there to be a recognisable pattern or flow. On the basis of Boltzman's Ordering Principle, there is zero probability for the occurrence of Benard's convection. Small convections occur as fluctuations from the average state, but below a certain critical value of the temperature gradient, these fluctuations are damped and disappear.

Prigogine does not see the world's population explosion as a threat. "The interaction between men has always generated ideas and development", he says. But it is difficult to believe that the 'ideas and development' that this interaction is likely to generate in the next decade will provide much solace to the billion or so people who are expected to die of starvation during this period.

However, above this critical value, certain fluctuations are amplified and give rise to a macroscopic current. A new molecular order appears that basically corresponds to a giant fluctuation stabilised by the exchange of energy with the outside world. This is the order characterized by the occurrence of what are referred to as *dissipative structures.*"

A third example that is constantly cited was first described by Von Neuman. It concerns the behaviour of small magnetized cubes which may occasionally by induced to organise themselves spontaneously and to form recognisable patterns.

Living Dissipative Structures

Living things, if they are in a state of change, can also fall into the category of dissipative structures. Among them, Prigogine cites the termites' nest and the slime mould, when in its multicellular state.

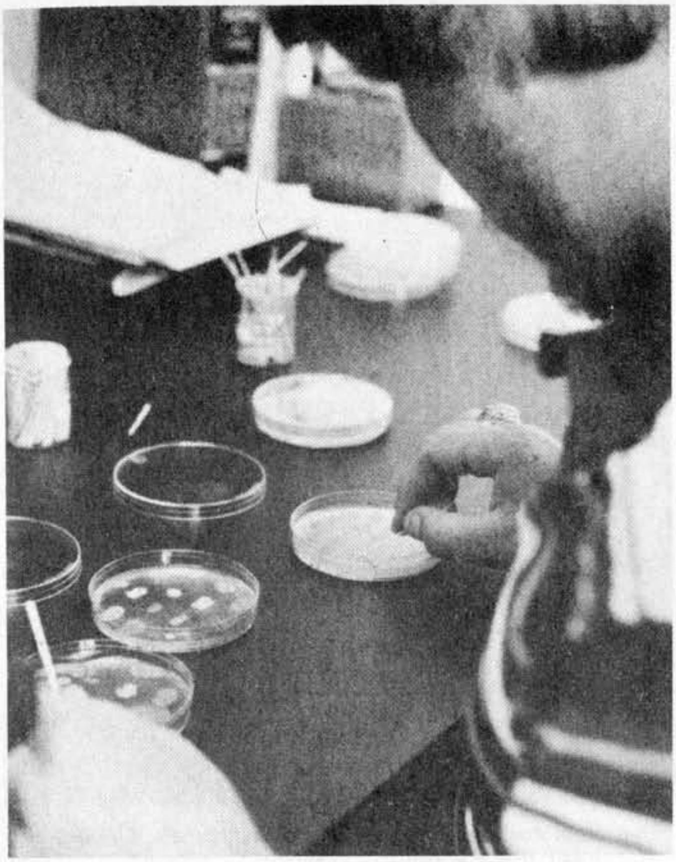
If these can be classified in the same category as Belousov-Zhavotinsky's spiral waves, Benard's whirlpool and von Foerster's magnetized cubes, it seems to be simply because, like the latter, they have emerged from a homogenous state, as a result of — to begin with — random fluctuations that have then become amplified.

Thus consider the development of a termites' nest. The first stage is uncoordinated and disorderly. Material is derived from various deposits which Prigogine identifies as fluctuations. A pillar or wall suddenly appears from a sufficiently large deposit and hence "from a sufficiently large fluctuation." Prigogine then tells us "that this state corresponds to the amplification of the fluctuation. Order therefore appears through fluctuation . . ."

Another example is the behaviour of the slime mould — a colony of largely independent amoeba, whose staple food is the bacteria *E. Coli.* When these become scarce, the amoebas react by simply joining together to form a mulit-cellular plant-like organism which, it seems, is better capable of surviving on the reduced food supply. For Prigogine[8], the behaviour of the slime mould provides but a further confirmation of his thesis. The original population of protozoa he refers to as a 'homogenous configuration' and he sees it as being transformed via a fluctuation into a non-homogenous structure.

If unstable living things are dissipative structures, so too are the components of the technosphere such as business enterprises and modern cities. Prigogine describes the process leading to the establishment of a factory in just the same terms as he does the building of a termites' nest. To begin with there is homogeneity in that the population is evenly distributed throughout the city; the building of the factory corresponds to a fluctuation. This leads people to concentrate in the vicinity of the factory in order to obtain employment, which corresponds to the development of a dissipative structure. As Prigogine puts it[10] "the appearance of this economic function will destroy the initial uniformity of the population distribution by creating employment opportunities that concentrate the population at a point".

By blurring in this way the essential difference between the behaviour of living things and that of inanimate things, Prigogine and Jantsch can legitimise the development of the world that the biotechnic revolution is likely to give rise to — to justify what Prigogine refers to as that "nouvel état de nature que



Genetic Engineering — not seen as an unacceptable risk by Prigogine and his followers but as a major challenge.

l'activité humaine contribue à faire éxister". He is quite explicit in insisting that the "développement de cette *nouvelle nature,* peuplée de machines et de technique, le développement des pratiques sociales et culturelles, la croissance des villes . . ." *is similar to the development of plants.* They are both 'processus continus et culturelles" — part in fact of the same evolutionary process.

So must of course be genetic engineering, thermonuclear fusion and the setting up of colonies in space, in fact all those developments that he regards as necessary for solving the problems that confront our society today.

Jantsch[11] provides even more outlandish examples of dissipative structures. He tells us that "God himself is like a dissipative structure as is the Buddhist Shunayta". The Universe he tells us "is itself comparable to a dissipative structure". Unfortunately, he does not tell us much about the amplified fluctuations which have led to the development of God, of the Buddhist Shunyata or of the universe.

Elsewhere he goes quite beserk in his enthusiasm for dissipative structures.[12]. "Possibly . . . stars and the cores of galaxies but certainly ecosystems, the world-wide Gaia System of the Bio-plus atmosphere . . social systems, civilisation and culture are no less dissipative self-organising systems than are ideas, paradigms, the whole system of science, religions and the images we hold of ourselves and of our roles in the evolution of the universe." Indeed to the faithful everything is seen either as a fluctuation or dissipative structure.

Popper[13] describes how the converts to Marx's Theory of History, Freud's psychology and Adler's Individual Psychology reacted in exactly the same way; "Once your eyes were opened, you saw confirming instances everywhere: the world was full of verifications of the theory and unbelievers were clearly people who did not want to see the manifest truth: who refused to see it, either because it was against their class interest or because of the repressions which were still 'unanalysed' and crying aloud for treatment."

Conditions in which Dissipative Structures will Occur

If Prigogine and Jantsch do not make it at all clear precisely under what conditions non-equilibrium steady-state structures will occur, they are still less clear as to the conditions required for the development of dissipative structures. Prigogine[8] tells us that "change from equilibrium chemical systems that include catalytic mechanisms, *may* lead to dissipative structures". Note the 'may'. Elsewhere[14], he tells us that"spontaneous formations of such structures" include "openness with resepct to the exchange of energy and matter with the environment, far from equilibrium conditions and auto or cross catalytic steps in the reaction chain. This last point means that certain molecules participate in reactions in which they are necessary for the format of molecules of their own kind (autocatalysis) or first for the formation of molecules of an intermediate kind and subsequently of their own kind crosscatalysis".

Jantsch[11, 12] is hardly more helpful. He tells us that "systems capable of dissipative self-organisation are open in their relations with the environment; internally far from equilibrium; organised in hypercycles (or their equivalent); autopoietic in their function (which also includes the internal reinforcement of fluctuation); structured in dissipative space-time structures; evolving through an indefinite sequence of structures; and as evolving into other systems in ultracycles".

How do they justify this vagueness? Presumably the laws governing the development of dissipative structures cannot be formulated with precision because, as Prigogine tells us, Nature is not governed by such laws. As he writes himself[10] "Les chemins de la nature ne peuvent être prévus avec certitude, la part d'accident y est irreductible: la nature bifurcante est celle où de petites differences, des fluctuations insignificantes, peuvent, si elles se produisent dans des circonstances opportunes, envahir tout le système, engendrer un régime de fonctionnement nouveau".

It must follow that the Prigogine-Jantsch paradigm, *has no predictive value,* and hence does not provide any useful information for controlling behaviour and adapting to environmental changes.

Why Non-Linear Thermodynamics?

What Prigogine does tell us about the conditions in which dissipative structures *may* occur is nevertheless significant. To begin with the system must be open to energy from the outside. 'Auto-catalysis' must also occur. This autocatalysis he describes[8] as the participation of certain molecules "in reactions in which they are necessary for the formation of molecules of their own kind". Presumably this is what is normally referred to as reproduction. Another condition is the occurrence of cross-catalysis; "the formation of molecules of an intermediate kind and subsequently of their own kind" — by which he presumably means the development of an informational medium, such as DNA, in which instructions will be formulated and translated into action (protein synthesis).

The question we must ask is why should it be Prigogine's amplified fluctuations that are responsible for giving rise to the dissipative structures, *rather than the highly complex conditions in which these amplified fluctuations occur?* The fluctuations may well be *but one small factor* out of a vast constellation of factors that together give rise to 'dissipative structures'. Why should we not regard the information contained in the 'molecules of an intermediate kind', for instance, as having given rise to the dissipative structures? Why not the availability of the complex materials out of which the various molecules are made? In other words why should the development of living things be regarded purely in terms of thermodynamics of whatever variety — i.e. in terms of the dissipation of the sun's energy on our planet — rather than in terms, for instance, of informational dynamics or biodynamics or ecodynamics?

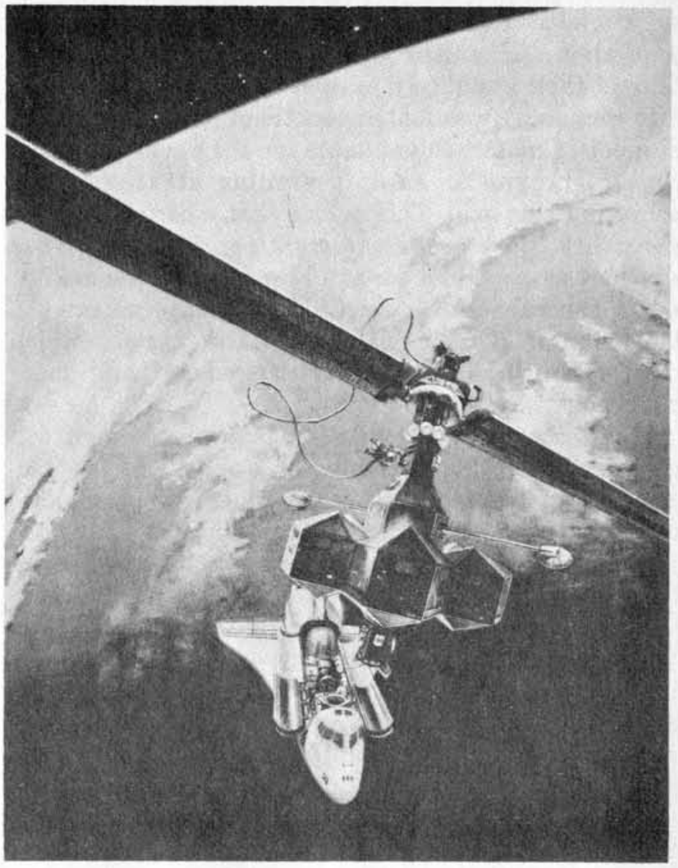
Let us take a simple process such as the cooking of that 'dissipative structure' which is a dish of roast beef and Yorkshire pudding. Prigogine would explain it entirely in terms of the effect on it (fluctuations) of the energy made use of. But why is the heat required to cook the roast beef more important than the skill displayed by the cook, the availability of the pan, the fats, the salt, the cook's motivation, her desire to please her husband and feed her family or to entertain important guests or, if she is an employee, the financial renumeration she will receive. This is not to mention, of course, the long chain of events which preceeded the cooking of the roast beef; its purchase at the butchers, the breeding and raising of the bullock, etc. In reality, the process involved, like all living processes, is an *incredibly complex one* — and to describe it simply in terms of the dissipation of energy and the fluctuations it gives rise to is to *impoverish* it to the point that it can only serve the interests of mystification and obscurantism.

Systems

It is quite a feat to persuade people that the Belousov-Zhabotinsky spiral waves, Benard's whirlpool, Von Neuman's arrangement of magnetised cubes, as well as paradigms, the whole system of 'science', religions, the images we hold of ourselves and our roles in the evolution of the universe, fall into the same catagory as cells, organisms, societies and ecosystems.

One of the expedients that Prigogine and Jantsch make use of to persuade people that this is so, is to make it appear that all these things fall into the category of 'systems' which means, of course, using the term 'system' in such a vague way that it can be used to apply to anything.

The most current definition of 'system' is that of Hall and Fagan.[15] They simply refer to it as a set of entities in dynamic interrelationship with each other, telling us nothing about the interrelationships or about the purpose and functioning of the set of entities. Such a definition can thereby apply just as well to 'natural' systems — the constituents of the biosphere — and 'unnatural' systems — those of the technosphere — or even purely arbitrary systems which play no part either.



New Scientist

Space colonies — our final goal according to Prigogine. But how are we expected to maintain populations in space when we cannot even sustain them on earth?

Delattre[16] uses the term system very much as do Hall and Fagan; "On peut definir la notion de système d'une manière tres générale en disant qu'un système est un ensemble d'éléments qui interagissent entre eux et éventuellement avec le milieu exterieur."

Jaques Monod[17] rightly criticises the use of the term as being too loose; "Quand on embrasse tout, on risque de ne rien embrasser du tout."

This is the point. If the category 'system' is to be of any use, then to show that something is a system is to convey important information about it — in particular to show that its behaviour is governed by a particular set of laws, those which govern the behaviour of systems in general. In the same way, the category 'mammal' is of value since to say that a particular form of life is 'a mammal' is to provide considerable amount of information about it. It is to tell us, in fact, that it will display all those characteristics displayed by other 'mammals', and hence that, at a certain level of generality, its behaviour will be governed by those laws that govern the behaviour of 'mammals' in general. For this reason. Von Bertalanffy[18], the father of General Systems Theory, rightly reserves the use of the term 'system' to "complexes of elements in interaction *to which systems laws can be applied.*"

I think one can be still more specific and define a 'system' as "a unit of behaviour with the biosphere" —

such as a biological organism, a tribal society and an ecosystem. Since their goal is the same, that of maintaining their stability (i.e. their basic structure in the face of change), we must expect them, given the limited number of materials available for the development of living things, to exploit similar strategies for achieving this goal. This means that a certain level of generality, *their behaviour must be governed by the same set of laws,* just as, at a lower level of generality, a less general set of laws can be shown to govern the behaviour of all 'men' regardless of the extent to which they differ in all sorts of less general and more superficial ways.

If the categories 'systems', 'mammal' and 'men' can constitute suitable variables of a model of the biosphere that has real predictive value, it is possible to invent categories that could not possibly be of any use for this purpose. Such a category would be the yet to be invented 'funkus' which we shall take to include the sub-categories 'cigarette ends', 'indefinite articles' and 'moonlit nights'. If this category would be of little use, it is that there is little of interest that can be said that applies at once to 'cigarette ends', 'indefinite articles' and 'moonlit nights'. It is difficult to formulate a valid set of laws which would apply to the behaviour of things falling within these sub-categories that would be of use in explaining the functioning of the world we live in. In other words, to say that something is 'funkus' does not convey any important information which enables us to predict how it is likely to behave. The trouble is that *exactly the same thing can be said of Prigogine's 'systems' as it can too of his 'dissipative structures'.* They are little more than glorified funkuses.

Of course to Prigogine and Jantsch, this may well be unimportant, since, as we shall see, they do not see the behaviour of living things as being bound by any specific laws — if behaviour is thereby random — so of course must be the units of behaviour.

Thus, when Jantsch tells us that the heterogenous assortment of things he classifies as a system, actually "live and evolve"[12], he is not in fact telling us very much of any value about them because for him, to "live and evolve", means very little. Both these processes are seen as purely random and thereby in no way distinguishable from other less sophisticated processes — such as the behaviour of inanimate things and in particular machines. Random systems indeed belong to a world in which there are no laws and in which all behaviour is random.

Order

Another concept that Prigogine and Jantsch misuse is that of 'order'. They try to make us believe that the order displayed by Belousov-Zhabotinsky's spiral waves, Benard's whirlpools, and Von Neuman's arrangement of magnetized cubes is the same as that displayed by living things. Though the pattern the former display is not random, in that it could undoubtedly be explained in terms of some or other physical principles, it is random to the world of living things within which the term 'order' means something very different. There are two ways in which the term is normally used in this context. The first is in terms of limitation of choice.

Thus one can talk of the multi-cellular slime-mould displaying greater 'order' than the colony of semi-independent amoeba out of which it arose. This is clearly not 'random order' but *a highly directive or purposeful one*; the members of the slime-mould colony do not organise themselves into a multi-cellular organism for the hell of it but because this enables them to face the new conditions more effectively than they could have done if they had remained in their former state.

The second way the term 'order' tends to be defined in the world of living things is in terms of *the influence of the whole over the parts,* which comes to exactly the same thing. Thus when the slime-mould is a loose colony, the influence of the colony, as a system, over its members is extremely weak — hence the wide range of choices the latter enjoy. When on the other hand, the colony is transformed into an integrated multi-cellular system, the influence of the whole over the parts becomes *correspondingly greater,* and their range of 'choices' correspondingly reduced.

This means that one cannot understand 'order' among living things unless *one sees a system within its correct context* — as part of the larger system in which it evolved and to whose influence it is subjected. As Thom[2] points out, what may appear to be disorder at the level of a molecule can in fact reflect a high level of order from the point of view of the cell of which it is part. Weiss[19] also shows how the parts of a cell are constantly changing, growing, dying, breaking up, recombining but that all this activity is, at the cellular level, fully under control. The apparent chaos is illusory; the influence of the whole (in this case the cell) over its parts is dominant and assures that the cell remains a viable unit of adaptive behaviour.

To understand their application of the term 'order' to the behaviour of living things, one must thereby introduce such notions as 'directivity', 'organisation', 'hierarchy' and 'levels of organisation' which are not part of the language of Aristo-science. Also it would be self-defeating for Prigogine and Jantsch to make use of these concepts for it would render their task very difficult of masking the essential difference between biospheric and technospheric processes.

Complexity

Another concept that Prigogine misuses is that of 'complexity'.

He is keen to prove that, contrary to basic ecological theory (see Elton), increased complexity is associated with growing instability.

The world, he points out, is becoming ever more complex — yet it is also becoming increasingly unstable. It is this instability that is reflected in the ever growing fluctuations that are everywhere apparent and which justify technospheric change and hence evolution and progress.

Professor Mellanby[20], and other establishment ecologists, also contest the old wisdom. Their reason for doing so is to justify the use of modern agricultural practices such as large-scale monoculture and the use of poisonous chemicals, which more objective ecologists know *must,* by drastically reducing the complexity and diversity of agricultural ecosystems, correspondingly increase their instability — a fact that is reflected in soil erosion, desertification and the increased incidence of pest infestations.

Both Prigogine and Mellanby regard the work of May as providing the justification for their thesis. May argues that the introduction of the Japanese beetle, the European gypsy moth and the Oriental chestnut blight in North America *increased the complexity of local ecosystems.* "It is trivial but not irrelevant to observe" he tells us "that stability was hardly enhanced by the extra links added to the trophic web in these instances."

On the contrary, he tells us, the "extra links" must inevitably increase *instability.* "The greater the size and connectedness of a web", he tells us, "the larger the number of oscillations it possesses: since in general each mode is as likely to be stable as unstable, (unless increased complexity is of a highly specialised kind) the addition of more and more modes simply increases the chance for the total web to be unstable." This absurd argument makes excellent sense if we define *complexity* as *random complexity,* calculated purely in terms of the number of randomly chosen and randomly interrelated parts or as a measure of the interrelated entities that display *'random order'.*

Mellanby sees this as providing a full justification for the simplification of agricultural ecosystems, Prigogine for the simplification of the biosphere as a whole and for the increased need for man's technological intervention.

But it does nothing of the sort. May[21] himself admits that *his argument is only true of mathematical models* and that its application is further limited to systems with an even number of species — a disquieting thought, if it were supposed to apply to the real world, but of no particular consequence if it is only to apply to a mathematical model. May's work is based on the mathematical models developed by Lotka and Volterra but, he tells us, "Whether or not the Lotka or the Volterra equations are applicable to the real world situation is *outside the point being made here,* which is that complex mathematical models are in general less stable than the correspondingly simple mathematical models with few species."

In the real world, May[21] admits, *things may be different.* "Natural ecosystems, whether structurally complex or simple" he writes "are the product of a long history of co-evolution of their constituent plants and animals. It is at least plausible that such intricate evolutionary processes have, in effect, brought about those relatively tiny and mathematically atypical regions of parameter space which endow the system with long-term stability." However, as May states himself[23], such an ecosystem is "mathematically atypical" and hence, he intimates *of little relevance to a mathematical model.*

It is significant that Prigogine, like Mellanby, takes as a justification for his views on the behaviour of natural ecosystems, the work of a writer for whom natural ecosystems are unimportant because they are "mathematically atypical".

In reality of course 'random complexity' is a *fiction*

For the faithful, everything is a 'dissipative structure', explainable in terms of 'Non-Linear Thermodynamics'. As Jantsch puts it: "God himself is like a dissipative structure as is the Buddhist Shunayata."

— just as is 'random order' or a 'random system'.

Complexity is above all organisation. To Prigogine it coincides with organisation — since he does not distinguish between complexity and diversity.[7]

In the real world, as Pittendrigh[22] points out, things only organise themselves *for the purpose of achieving a given goal.* "There is no such thing as organisation in any absolute sense, pure and simple" he writes, "organisation is always relative and relative to an end." What is more, within the biosphere there is only one overall end. It is adaptation to the environment. Thus "to say that living things are organised is to say they are adaptive." "If there is beneath the great diversity of nature an underlying similarity of design" Pittendrigh writes "it is that all living things *share the same purpose.*" (To achieve the goal in an *orderly* environment of course means developing the appropriate complexity; to achieve it in a disorderly environment requires the development of the appropriate diversity).[7]

If the general design is the same, its details vary from one system to another. What is more, in any such organisation — an ecosystem for instance — each sub-organisation or sub-system has a specific role to fulfil in assuring that the organisation, or system as a whole, achieves its overall goal i.e. its stability. For this reason the parts of an ecosystem are not *interchangeable* as they would be if its organisation were random and if it tended towards a random goal. It follows that the only thing that was really increased by the introduction of the Japanese beetle, the European gypsy moth and the Oriental chestnut blight in North America was *randomness* and *disorder*, which *reduced* rather than *increased* real biospheric complexity and stability.

If the introduction (into an ecosystem) of forms of life which evolved as the differentiated parts of a very different ecosystem reduces rather than increases complexity, still more is the complexity of the biosphere as a whole reduced as we pollute it with fusion reactors, genetically engineered microorganisms and all the other things that Prigogine refers to misleadingly as "Le Nouvel État de Nature."

These are the components of a super-duper technosphere — an organisation of matter that is in direct conflict with the biosphere from which it derives its resources and to which it consigns its increasingly toxic waste.

Technospheric 'complexity' is thus not only different from biospheric complexity but *diametrically opposed to it.* The former can only increase at the cost of correspondingly reducing the latter.

It is true, as Prigogine tells us, that the world is becoming ever more complex, also it is becoming correspondingly more unstable. What Prigogine does not tell us however is that the increased complexity he refers to *is technospheric as opposed to biospheric complexity.*

Nor does he tell us that this increased technospheric complexity is being achieved at the cost of correspondingly reducing the complexity of the biosphere nor, of course, *that it is to this reduced biospheric complexity that the current instabilities must be attributed.*

Structure and Process

Jantsch[9] makes use of another expedient for rationalising his idea of perpetual technospheric change. He tells us that "the evolutionary perspective emphasises *process over structure,* the exchange of energy over its containment, flexibility and change over stability." Elsewhere he tells us that structure "is an *incidental* product of interrupted processes, no more solid than the grin of a cheshire cat."

Neither Prigogine nor Jantsch attempt to define 'structure'. In normal language it means organisation and hence complexity (unless of course complexity is distinguished from diversity). Since complexity and diversity are taken to be random, their structure is indeed *'incidental'.*

However it is nonsense to talk of processes as being of more importance than the structure with which they are associated. All structures exist in *time* as well as *space,* and all processes exist in *space* as well as in *time* — so much so that one cannot really distinguish between the two. The fertilised egg that develops into a foetus, and then into a human adult, who ages and eventually dies, can be seen either as a *particular* *structure* or as a *particular process* depending on whether one wishes to accentuate its *spatial* or its *temporal* aspect. If a structure or organisation is random, or 'incidental', then *so must be the associated process.* This means that 'process' for Jantsch cannot be 'life process' (which is goal directed and highly orderly) but must simply refer to chaotic uncontrolled change — the sort of change that, at a biological level, occurs in cancerous tissue, and, at a social level, in an anonymous mass society that is moving, as is ours, ineluctably towards collapse.

Jantsch[9] admits this in so many words. For him a process "does not just seek peace with the world or some action of homeostatic relationship, it acts upon the world and *stakes its own claim* . . .", although he admits that there may be certain 'guidelines' which affect "the overall structure". Elsewhere[11, 12], he tells us that a process "seeks its own way and finds its own justification in itself, not in any external regulator or guarantor."

In other words Jantsch's process is in no way subject to biospheric control, which means that it cannot be an integral part of the biosphere (i.e. homeotelic to it[7]). On the contrary, it must be *purely random* to it.

Stability

Another concept which Prigogine and Jantsch misuse is that of 'stability' which for them is a feature of those 'steady-state non-equilibrium structures', such as planets and crystals, whose behaviour we are told is still governed by Boltzman's Ordering Principle. It is not, on the other hand, a feature of living things, that are classified as 'dissipative structures' and that are brought into being by amplified fluctuations. In their efforts to prove this thesis, Prigogine and Jantsch constantly allude to an article by Holling, a Canadian ecologist, that is worth considering in some detail.

Holling[23], like Prigogine and Jantsch, sees stability as something that is undesirable For him stable systems, in which category he includes living things that have not been subjected to change for a very long time, are not persistent and are, for this reason, unsuccessful. Successful systems, like Prigogine's 'dissipative structures', are necessarily unstable and Holling refers to them as 'resillient'.

The first point one must make is that living systems that have remained constant over long periods *are the rule rather than the exception.* In fact, the most striking feature of the behaviour of living things during the last three thousand million years is not their ability to change but, on the contrary, their extraordinary constancy. Many forms of live have not changed at all for hundreds of millions of years, a fact that is difficult to explain in terms of current evolutionary theory. Thorpe[24] refers to it "as the problem of fixity in evolution." "What is it", he asks, "that helps so many groups of animals to maintain an astonishingly constant form over millions of years? This seems to me to be the problem now — the problem of constancy rather than of change . . . These problems seem to me to stick out like a sore thumb in modern evolutionary theory". Both Huxley and Waddington have been struck by the same dilemma. Darwin himself, as already mentioned[7], stated in a letter to Lyell that, if he had to start again, rather than use the term 'natural selection' he would use 'natural preservation.'[25]

There is another objection to Holling's thesis. For him a stable system is one that is capable of returning to an 'equilibrium state' after a temporary disturbance and "the more rapidly it returns and with the least fluctuation, the more stable it is." In other words he regards a stable living system as 'homeostatic' and its behaviour as similar to that of a thermostat which assures the constant temperature of, say, a centrally heated apartment by bringing it back to a pre-determined norm after a temporary diversion. As usual, a comparison between the behaviour of machines and living things is misleading, for the experience of the thermostat is *reversible* (so long as we ignore the minute effects of wear and tear), while among living things, as both Prigogine and Jantsch themselves point out, time and experience are *irreversible.*[7] They are thus being most inconsistent when they adopt, with Holling, a definition of stability that *assumes the reversibility of time and experience.*

In reality, living things do not react to a disturbance by returning to a pre-disturbance state. Every disturbance, however temporary, must affect them, if only to assure that when it recurs, they are *better capable of dealing with it,* so that it gives rise to a smaller fluctuation.

In other words, natural systems *learn* and this means that they can maintain their stability in a constantly changing environment in which machines would rapidly become unstable.

Living things must thereby be seen as *dynamic* rather than *static,* and stability, instead of being a point in space-time towards which they tend, must be regarded as a course along which they must move in order to minimise change i.e. so as to achieve a climax state (see the Second Law of Ecodynamics)[7]. When this state has been achieved, stable systems will continue to change, but at a very reduced rate, as the climax is the most stable (and hence the most desirable) state and all but minimal further change cease to be necessary.

Waddington[29] refers to such a course as the "chreod" (from the Greek *chre* — it is fated or necessary and *Hodos* — a path) though he does not describe it in the technological language I make use of. The nature of the 'chroed' that a system must adopt is determined by the instructions it contains in its genes and other organisations of information, in interaction with the environment within which it travels which Waddington refers to as the "epigenetic landscape".

Living systems, rather than display *homeostasis,* he sees as displaying *homeorhesis* (from the Greek *homeo* — same, *rheo* — flow). To quote Waddington[29], "We use the word 'homeorhesis' when what is stabilized is *not a constant value but is a particular course of change in time.* If something happens to alter a homeorhetic system and control mechanisms do not bring it back to where it was at the time the alteration occurred, but *bring it back to where it would normally have got to at some later time.*"

As a living system moves along its chreod, it is constantly subjected to fluctuations, the size of which must of course vary. Thus the behaviour of a system functioning in a highly orderly environment (such as that which exists within our bodies) will be characterised by *small fluctuations;* that of systems functioning in a disorderly environment, by *much larger fluctuations.*

The former will ressemble, up to a point, what Holling refers to as stable behaviour, though not exactly. Our body's internal environment is not immobile — it consists of innumerable processes that have moved along the 'chreod' corresponding to our optimum embryological and ontogenetic development. The latter behaviour, that which occurs within a disorderly environment, is characterised by large fluctuations and is, thereby, what Holling regards as 'resilient.'

The distinction between the two, however, is not as critical as Holling makes out for *the goal of both types of behaviour is the same: to maintain stability in the face of change.* Of course, in the latter case, the change is greater than in the former, which means that the strategy required to achieve the goal is somewhat different. However, to say that the former system is *stable* and the latter *unstable* is simply nonsense. As Waddington[29] writes, Holling's distinction between stability and resilience is simply based *"on a confusion between two different types of stability."*

It is true that those highly integrated systems whose behaviour is subjected to smaller fluctuations (and thereby correspond most closely to those that Holling regards as stable) have become so specialised, and hence so committed to a very specific environment, that they are correspondingly vulnerable to unexpected environmental changes. This does not mean, however, that they are 'inpersistent' and hence 'unsuccessful'. If they were not highly persistent and highly successful, there would be no biological organisms on this planet — since the systems that make up their internal environment *all fall within this category.* It does mean, however, that such systems must be insulated in some way from the rigours of the external environment. *If nature did not provide such insulation, then Holling would be right but in all but the most aberrant man-made conditions, nature always obliges.*

The centralisation of our nervous system and the development of the neo-cortex enables us, for instance, to deal with environmental challenges and hence to insulate our internal environment. But in addition, further insulation is provided by the family, whose own internal environment is further insulated by the community of which it is part. Less highly perfected ecological mechanisms also exist to insulate all sorts of primitive forms of life that have not changed over long periods from radical environmental challenges.

As we move from the internal environment of an organism to that of the family and the community, so is behaviour increasingly 'resilient', to use Holling's term, i.e. it is characterised by larger fluctuations. It is not very helpful to say that this resilience is more desirable than the less resilient behaviour that occurs within the organism *since the function of behaviour within the community is above all, as we have seen, to insulate the behaviour which occurs within the family and the organism from external challenges, i.e. to help maintain their stability.*

In addition, if external conditions become too challenging, it is the larger, more resilient systems that first collapse, not the smaller, more 'stable' ones (in Holling's terminology) as the history of the progressive breakdown of our society clearly reveals. So Holling has got it *all* wrong.

There is however a critical distinction to make. It is not between systems displaying small fluctuations and those that display large fluctuations, but between *those whose behaviour is characterised by constant or decreasing fluctuations and those whose behaviour is characterised by growing fluctuations.* The former we can regard as *stable,* the latter as *unstable.* In the former case, fluctuations are *under control,* the system being capable of dealing with the challenges of its environment, in the latter case, they are *out of control* i.e. the challenges are of a sort that the system cannot deal with adaptively. Such systems are, of course, condemned to disintegration and extinction.

Holling regards the ideal system, the one with the appropriate resilience and persistence as falling within the former category i.e. as being subjected to big — though not necessarily increasing — fluctuations. Such a system in my language (also Waddington's) is *stable.* Prigogine and Jantsch, on the other hand, sing the praises of systems with growing fluctuations i.e. *unstable systems.*

For this reason Holling's argument, even if it were valid, would only very superficially support the Prigogine paradigm.

There are No Laws

If behaviour is random, then it is not governed by any precise laws. This, Prigogine and Jantsch explicitly accept. Being Aristo-scientists, by 'laws', they mean the 'laws' of physics and thermodynamics. In fact, for Prigogine, the only *universal laws* are those of classical thermodynamics. But these only apply to those things that are 'near thermodynamic equilibrium' i.e. that are in a state of homogeneity. To quote him[10] "Les seules lois macroscopiques universelles sont bien les lois qui decrivent l'évolution vers le dèsordre, vers les états dèquilibre ou les états stationnaires proches de l'équilibre mais ces lois physiques ne constituent pas le context par rapport auquel le vivant doit se definir: non pas parce qu'il est vivant mais parce que, physiquement, il ne remplit pas les conditions d'application de ces lois, les conditions sous lesquelles ces lois sont pertinentes."

In other words, since living things do not fall within this category, the laws of classical thermodynamics cannot apply to them, and since there are no other laws, it must follow that *the behaviour of living things is not subjected to any laws at all.* All this sounds very much like the worst type of Mediaeval casuistry. Yet Prigogine assures us that it is the only possible position that a scientist can adopt, for it is the only one that is reconcilable with the statistical theory which is so fundamental to modern science. As Needham[26] assures us, laws are but words we give to statistical regularities, "valables uniquement pour des temps et des lieux donnes, en termes de description et non de prescription."

When the Newtonian paradigm was in fashion, Prigogine admits, there were indeed Laws. However it was by specifically rejecting the notion that nature was governed by laws that it became possible to free science from the 'Newtonian myth'. "La Science échappe au mythe Newtonien" Prigogine[10] tells us "parce qu'elle a conclue théoriquement à l'impossibilite de reduire la nature à la simplicité cachée d'une réalité régie par des lois universelles."

Morin[27], who is deeply steeped in the Prigogine mythology, tells us that it is only in "popular epistemology" that one finds reference today to the laws of nature. In other words only the stupid and the uneducated still believe that nature is governed by laws. Modern science has abolished them all and has thereby liberated man so that he is now free to create his own laws, to determine the course of his own evolution, and hence his own destiny. This is the essence of Jantsch's message in *The Self-Organising Universe.* "Evolution is basically open," he assures us. "It determines its own dynamics and direction. This dynamic unfolds in a systemic web which, in particular, is characterised by the co-evolution of macro and micro systems. By way of this dynamic interconnectedness, *evolution also determines its own meaning.*"

In reality of course nature is bound by a very large number of different laws. What is more they are very much more than 'statistical regularities' and they are 'perscriptive' too.

As Waddington[28] points out, laws are best seen as *constraints.* Among other things, the term constraint is only meaningful in a *teleological context* i.e. as a constraint that must be observed *in order to achieve a specific goal.* Since living things, as already seen, tend towards the same goal, it must follow that, at a certain level of generality, they also tend to be governed by the same constraints or laws.

These laws are not binding in an absolute sense of the term — it is this that confuses our Aristo-scientists — but *if they are not observed* then the systems bound by the law will not achieve their goal. They will become unstable and hence fail to survive.

Thus men *can* walk over cliffs, refrain from eating and drink cups full of cyanide — but if they do this they will not be around for too long.

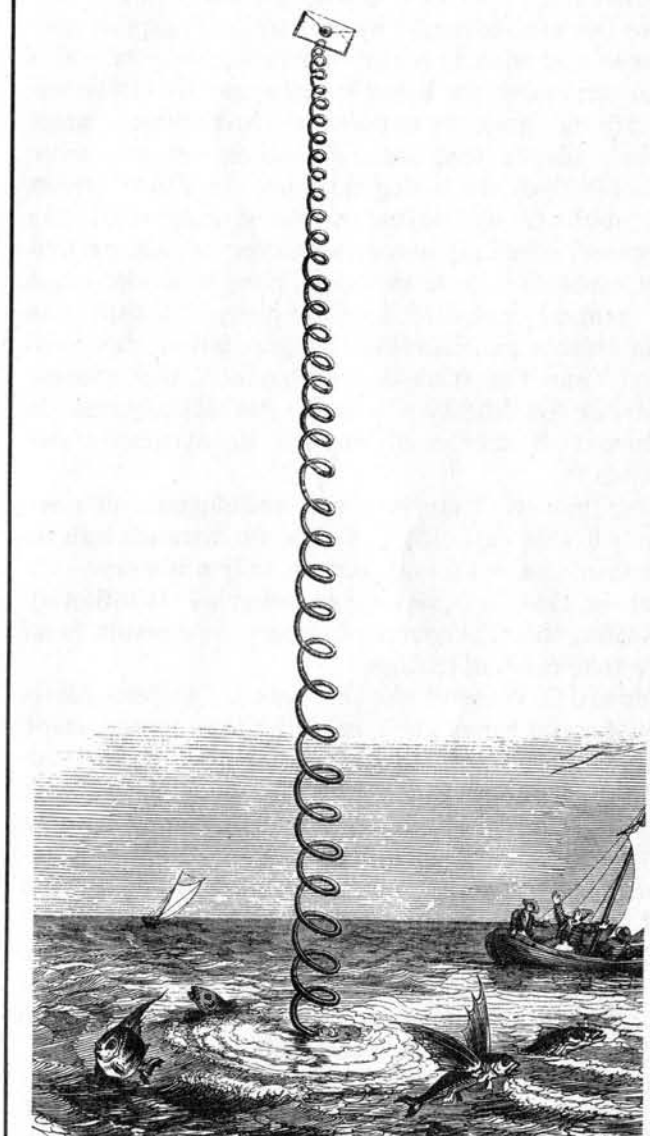
Similarly, the general laws governing the behaviour of biological, social and ecological systems *are those that must be observed, if these organisations are to remain stable and hence survive.*

The systems that make up the biosphere are thus 'prescriptive', contrary to what Needham tells us — prescriptive for the achievement of their goal and hence for the achievement of biospheric stability.

Once more, however, this is not apparent to scientists who deny the validity of such key concepts as 'organisation' and 'teleology' without which one cannot understand the world of living things.

Malleability

We have seen that, in order to rationalise the desirability of perpetual technospheric change, Prigogine and Jantsch have tried to show that, within the biosphere, units of behaviour or systems are of a purely random nature; that stability is self-defeating; that 'structure' is random too and also of little importance, no more so than the "grin on the face of a Cheshire cat"; that only 'process' is important — though it is also random and hence subject to no laws.



"Don't worry! It's only a dissipative structure!"

In other words, the world of living things is *infinitely malleable.* Anything goes.

Prigogine and Jantsch are not the first to have tried to justify the transformation of the world of living things under the influence of development by an appeal to the infinite malleability of man and nature. Lemarck tried to do so. It was his principal error. He assumed that man could adapt genetically to short-term environmental changes which meant that he could constantly undergo radical structural and behavioural changes, which of course, it is precisely the goal of behaviour in the natural world to prevent. Lemarck, as Piaget[29] puts it, compared "L'organisation héréditaire à un liquide épousant les formes de tous les récipients sans stabilité ni même, en principe, sans l'irréversibilité de nature historique."

Instead, as we know, the hereditary material is relatively non-plastic, unmmodifiable by the short-term experience of a species — though almost certainly not, as neo-Darwinists imply, by its long-term experience.

Those who wish to justify the radical way in which social structures are being transformed by the industrial process, must try to persuade themselves, against all the evidence, that social structures are *even more malleable* than are biological ones. As Ellul[30] writes "On souhaite en réalite (même si cela n'est pas clairement exprimé) une organisation sociale *parfaitment malléable:* car la technique pour progreser éxige une grande mobilité sociale puisqu'il faut des déplacements considerables de population, des mutations dans l'exercise des professions, des changements de qualification sociale, des affectations de resources et des modifications de structure des groupes."

Most modern historians and sociologists also see society in this way. H.A.L. Fisher, for instance, tells us that man does not have a nature, only a history — intimating, thereby, that human behaviour is infinitely malleable, that the course of history, as a result, is no more than random change.

Edward O. Wilson[31] also talks of the "extreme plasticity of social behaviour", implying that we can adapt to living in just about any social environment, including of course, that which the industrial process imposes upon us — an environment composed of a structureless and anonymous mass of alienated individuals, one that could not differ more radically from that to which we have been adapted by our evolution.

The opposite of course is true. Like all living things, we are capable of adaptive behaviour because our biological and social structure, rather than being random and hence malleable, is on the contrary highly specific. The behaviour associated with it is very *specific,* governed by a very *specific* set of laws. It is goal-directed but the goal rather than the perpetual change is, on the contrary, the maintenance of *stability* i.e. the preservation of both our own basic structure and that of a very *specific* social and physical environment which must closely ressemble that to which we have been adapted by our evolution. To say that it is adaptive means that it can correct superficial divergences from this ideal environment but not more profound ones, such as those imposed by development and industrialisation and in particular by the super-star technologies that Prigogine and Jantsch propose — and which can only lead to the annihilation of complex forms of life on this planet.

The Self-Organising Universe

Jantsch's universe like Prigogine's is above all a self-organising one. At the same time, both of them insist that the evolutionary process is a man-made one. Prigogine tells Salomon, if we remember, that it is only by means of high technology, the development of thermonuclear fusion, genetic engineering and the building of colonies in space that we can solve our problems. How can they reconcile these two apparently irreconcilable positions?

There is only one way in which it can be done. *It is to identify man with the Universe.* If Prigogine and Jantsch can succeed in doing this (and they have performed other equally impressive feats of intellectual acrobatics), then the universe can be seen once more as self-organising. But how can their disciples be persuaded that man and the universe are one? Again there is a well-established expedient that can be exploited for this purpose. It consists in desanctifying nature and then, by attributing to man some key super-natural faculty that no other living things possess, to sanctify him in its stead.

In this way, our theologians have insisted that only man possesses a soul, a new idea since, when nature, too, was regarded as holy, all living creatures were also assumed to possess souls.

With the rise of rationalism in Europe came the notion that only man was capable of "rational" behaviour, the behaviour of non-human animals being guided by blind-instinct alone.

For Prigogine and Jantsch, man's holiness is bound up in his possession of a *mind* and hence of *consciousness.* Consciousness for Prigogine and Jantsch represents the highest state of evolution, as in the Noosphere of Teilhard du Chardin. Once this stage is achieved, the whole universe can be identified with consciousness and it is this consciousness that determines the course of further evolution.

It is because man possesses consciousness, Jantsch tells us that "mankind is not redeemed by God but redeems itself."

The evolution of *consciousness* then becomes synonymous with the evolution of the universe. To quote Jantsch, "Natural history including the history of man, may not be understood as the history of the organisation of matter and energy. But it may also be viewed as the organisation of information into complexity or knowledge. Above all however, it may be understood as the *evolution of consciousness,* or in other words, *of autonomy and emancipation — and as the evolution of the mind . . . Mind appears now as self-organisation dynamics at many levels, as a dynamic* which itself evolves. In this respect, all natural history is also history of mind. *Self-transcendence, the evolutionary processes, is this evolution of the mind.*"

If we are to attain Jantsch's mystical paradise, it is because the human consciousness is moving us in this direction, via the ever greater fluctuations that it engenders. To subject these fluctuations to any biological, ecological and social constraints would be to divert us from this optimum course and hence to deprive us of all the delectable dissipative structures that otherwise lie in wait for us. For this reason man's every conscious whim, caprice and self-indulgence must be immediately satisfied, in particular those that involve the introduction of the super-star technologies that Prigogine and Jantsch so strongly favour, regardless of the biological, social and ecological destruction that their introduction must inevitably bring about.

This provides the ultimate rationalisation of individualism, egoism and irresponsibility — the invisible hand gone beserk. Not only is it now seen as assuring our material prosperity but of determining too the very functioning, and hence the evolution of the biosphere itself.

The New Ecology

Surprisingly enough both Prigogine and Jantsch regard their message as highly ecological. They see consciousness-made evolution or the further 'self-organisation' of the universe as leading to a 'new alliance' between man and nature.

Monod[10], let us remember, told us that the evolution of man cannot be deduced from basic physical and thermodynamic laws. Since there are no other laws, man must be the product of pure chance. This meant that the old pre-scientific alliance between man and nature could no longer be justified. Man is isolated, Monod tells us, in a world in which he is but a stranger.

Progogine called his most famous book *La Nouvelle Alliance.* It was basically an answer to Monod. Its thesis was that the new non-linear thermodynamics, which he had invented, had brought man back once more into contact with nature. Man, for him, is not the product of chance, as Monod told us, for his occurrence is at least consistent with non-linear thermodynamics which explains how the dissipation of the sun's energy gives rise to dissipative structures of which man is the most highly perfected example. What is more, once we have all become genetic engineers, so must we become correspondingly more integrated into this world of living things. To Prigogine[10], genetic engineering is a highly ecological activity, even a 'poetic' one. ". . . Notre science" he writes "occupe la position singulière d'écoute poètique de la nature — au sens étymologique où le poète est un fabricant — exploration active, manipulatrice et calculatrice mais désormais capable de respecter la nature qu'elle fait parler."

Jantsch goes still further. The 'new alliance' that Prigogine has discovered gives new meaning to life. It provides a new sense of connectedness and "this connectedness of our own life processes with the dynamics of an all embracing universe has so far been accessible only to mystic experience. In the synthesis, it becomes part of science which in this way comes closer to life."

So we have a new ecology. Eugene Odum and Paul Ehrlich take heed: the study of a poetic and mystical self-organising universe, brimfull of genetically engineered dissipative structures, brought into being by consciousness-assisted randomly amplified fluctuations. God help us.

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Books

Self Immolation

NO NUCLEAR WEAPONS. Peter Kennard and Ric Sissons. Pluto Press, £1.00.
HOW TO MAKE YOUR MIND UP ABOUT THE BOMB. Robert Neild. Deutsch, £2.95.
DESTRUCTION OF NUCLEAR ENERGY FACILITIES IN WAR. Bennett Ramberg. Lexington Books. £12.50.
TOWARDS A NUCLEAR HOLOCAUST. Sir Martin Ryle. Menard Press, 75p.
SECRET FALLOUT. Ernest Sternglass. McGraw Hill, USA.

Those who aren't indifferent, apathetic and generally unthinking about world problems tend to have strong views about the notion of deterrence and Britain having the bomb. Each side in the debate argues with equal vehemence that peace and freedom are the gains to be had from following its preferred policy. In simple terms the pro-bomb adherents claim that nuclear weapons, together with the means to deliver them, are all that keep the enemy — namely the Russians — from daring to go too far, either with its inherent expansionist policies or by embarking on any venture likely to end in war with the Western Powers. Thus, they argue, only through having the bomb can the West and the free world remain free; otherwise skittle-like one country after another will follow Afghan and fall under Russian domination. Blake Baker in *The Daily Telegraph* and others take the argument further. According to them 'reds under the beds' are a real threat; indeed Russia, through communist sympathisers and its agents, is taking over CND and other ecological organisations. To be anti-bomb is therefore synonymous, says the Tory Press, with being dangerous, subversive and paving the way for the Communists — in short, hastening the end of peace and freedom.

Even though tending to be on the left, the other side brushes aside the accusation of it being pro-communist and for Russia. It sees the proliferation and elaboration of nuclear weapons as unstoppable both within countries that already possess a deterrent and within an increasing number of countries outside the traditional line up of east and west. And despite some form of non-proliferation treaty and arms control within the two superpowers — the Americans and Russians — the suspicion must remain, claim the anti-bomb lobby, that one or the other is pulling a fast one in order to gain the edge over the other; hence another round of technological advances and a tightened grip on the trigger which when pulled will unleash a barrage of world-destroying missiles. Such suspicion and fear within the military establishment is taking the world closer to the point of nuclear holocaust. Equally important, the deterrent swallows vast sums of money which otherwise could go towards alleviating chronic human suffering, such as lack of food and a reasonable place in which to live and work.

Not one of the five books is for deterrence and having the bomb. Peter Kennard's and Ric Sissons' venture for CND, with its grim photomontage and concise text, puts the anti-bomb message in a direct compelling way. The facts are displayed for impact: military expenditure in the world still soaring and now totalling more than half a million million dollars: more than 50,000 nuclear weapons shared out between the US and USSR, enough to wipe us all out many times over. At best we can smile wryly at Khrushchev's famous remark, 'We're satisfied to be able to finish off the United States first time round. Once is quite enough. What good does it do to annihilate a country twice? We're not bloodthirsty people.'

But facts, however disturbing, do not answer basic questions about the efficacy of deterrence. If for example we could be assured that deterrence was the only factor which would prevent major wars in a turbulent, essentially bad, world, would we be for or against? Is it legitimate to use an evil device for the good purpose of peace? Sir Martin Ryle's book *Towards a Nuclear Holocaust* is a step-up from the CND's blatant propaganda in that he tries to show us how the build-up both in nuclear weapons and delivery systems can have only an inevitable outcome — the destruction of the planet.

As Sir Martin explains, deterrence loses its reality when 'First-strike capabilities' are developed which can obliterate the enemy's delivery systems including submarines. Weapons therefore become offensive in nature rather than defensive since no side can wait to be attacked; it must get its missiles out of their launch systems and targetted on the basis of little more than suspicion that the other side has fired first. As Ryle points out 'a First-strike capability when owned by both sides must lead inevitably to a situation of complete instability'.

Why should one or the other Superpower be the first to fire? The syndrome is one we are all familiar with, suggests Sir Martin; a faulty warning system combined with the eradication of the human element, owing to the need to respond more and more quickly as missiles are made to reach their potential targets more swiftly and accurately. Indeed the launch takes place before anyone has really realised what is happening. Then again, one of the superpowers may attack when it considers itself to have a clear advantage, wiping out most of the launching sites of the other. It would then have the option whether to destroy cities and industrial installations.

After pointing out the consequences of nuclear war, Sir Martin suggests that Europe should become non-nuclear as a first essential stage in the disarming of the superpowers; a safe storage place for all the plutonium would then have to be found — perhaps under UN control; moreover, since all reactors produce plutonium he would do away with them too.

In his very readable and convincing essay, Sir Martin makes no attempt to temper his plea for disarmament. Like many others he sees time running out. But there are some people who need irrefutable logic before they can make their minds up about the bomb. They feel that Britain, in return for guaranteed protection from the States, should take some of the onus of harbouring nuclear weapons: they haven't yet grasped, it seems, that Britain as well as parts of Eastern Europe could well be expendable in an interchange of missiles between the superpowers simply as a warning of how terrible for them any further escalation might be. If only all those, including our own self-righteous prime minister, who cling pugnaciously to the idea of Britain having a nuclear deterrent, would read Robert Neild's admirable *How to Make up Your Mind About the Bomb.* As he explaines Britain's possession of atomic weapons has as much to do with Britain's increasing impotence as a world power, with its empire slipping away in the immediate post-war era, as to a fear of the Russians. Moreover Britain was piqued that after the United States had used British scientists to help prepare the bombs dropped on Nagasaki and Hiroshima it excluded them from participating on further work immediately after World War Two. Like the French, the British wanted to prove that they too could make atomic bombs, and entirely on their own. But then Britain had overlooked the sheer nonsense of trying to keep pace with the giants. Russia could swamp it thousands of times over. Consequently Britain's stab at having an independent strike force led to its becoming increasingly subordinate and indeed subservient to the United States which soon was using Britain to establish its own nuclear bases. The anomalous situation now exists that the United States could carry out a nuclear strike from British bases without even having to get the British government's agreement.

Be that as it may, Neild is more concerned at the unbalancing effect American bases in Britain are having on the build-up of weapons in the two superpowers, and he repudiates the argument used by the government that Britain's increasing commitment to atomic weapons will serve the purpose world-wide of ensuring arms control. The perversity of that logic emerges in Britain's adherence to the notion of non-proliferation.

Neild sets out to demolish some of the bugbears that pervade establishment thinking in the West. Thus he suggests that the Russians have become little more than old-fashioned imperialists struggling to keep their increasingly unruly satellites in order. The build-up of troops in eastern Europe, the foray into Afgan, however despicable, are primarily garrison troops, although the USSR could never admit as much. No, it claims, the troops are there because of a corresponding build-up of troops by the West.

Neild also points out that the Americans, by consistently overestimating the Russian build-up of arms, have therefore justified their own drive for overwhelming superiority. The fear and suspicion that superiority engenders in the Russians can have only one consequence — to increase the impetus of the arms race. In essence Neild sets out to show how the flexible response concept, with nuclear weapons based in Europe, would be for Britain and the rest of Europe, 'an act of self-immolation without precedent'. He decries the secrecy with which successive British governments commit Britain both to its own nuclear weapons and to having American bases. Finally, as he rightly points out, the possession of nuclear weapons does not give a nation super power over another, nor does it prevent wars. The wars fought with conventional weapons since Hiroshima and Nagasaki give the lie to that notion. And surely it is nought but fanciful thinking that war would have long ago occurred between the United States and Russia but for nuclear weapons. On that basis the United States with its then-indisputable lead in nuclear weapons and delivery systems should have wiped Russia out at the time of the Berlin airlift.

The Israelis were not the first to consider nuclear power facilities as a prime target, but clearly they were aware that to have blown up the Iraqui reactor when fully loaded with fuel, and operating, would have been an act of unforgiveable criminality. Just how bad the consequences of attacks on nuclear energy facilities might be is delineated in Bennett Ramberg's academic venture, *The Destruction of Nuclear Energy Facilities in War.* Several years ago in discussion with the atomic energy authority I was told that nuclear power stations would be immune from attack by conventional weapons. They would not be able to penetrate the containment. The Israelis have blown up that notion, and furthermore have made Ramberg's hypothesis take on a convincing reality. Ramberg's approach is conventional in that he looks at an ascending scale of hypothetical accidents which have been studied in the United States and Western Europe for light water reactors; he then extrapolates to a situation where the reactors and other nuclear energy facilities are damaged in war to give equivalences in damage corresponding to the accident scale. His conclusions are fairly obvious in that a megaton bomb will immediately cause far more damage and fatalities than a spewing out of disintegrating fuel and fission products from a reactor. The long term fatalities from a destroyed reactor are likely however to exceed those from a nuclear weapon, furthermore the persistence of long-lived fission products on the ground and soil will keep contamination levels high. The worst combination of events is a reactor wholly destroyed by a direct hit with a nuclear missile, which consequently vapourises all the reactor contents.

Ramberg discusses too the capability of modern conventional weapons to penetrate and blast apart increasing thicknesses of reinforced concrete and armour-plating. A reactor can also be severely damaged through sabotage, particularly if the assailants are well-versed in the reactor's weak points. Ramberg considers nuclear energy facilities to be prime targets, particularly in a conventional war — as he stresses, the knocking out of a country's industry is one way to win. But he does not come out against nuclear power, rather he believes reactors should be buried underground. Perhaps the next time the CEGB wants to build a nuclear reactor we should insist that for our safety it is sited completely underground. But then, even the Board might baulk at the cost.

Secret Fallout is a modernisation of Sternglass's original *Low-level Radiation.* Attempts to pillory and discredit Sternglass continued unabated, and a more timid man might have desisted from his efforts. Nevertheless Sternglass has continued to put information together purporting to show that fall-out from nuclear bomb tests and from reactor operations have led to a plethora of fatalities, particularly among the unborn. I find his book fascinating, on account of his clever detective work and his exposure to blatant cover-ups by the nuclear industry. In that respect his story of the Shippingport reactor — the first ever land-based commercial PWR in the United States — is well worth reading: How a radiological investigative company was prepared to cover up and admit to incompetence in order to explain away embarrassingly high radioactive readings in the soil around the reactor. Either Sternglass is a deviously clever man with a penchant for fabrication, or else, as Nobel Prize winner George Wald believes, 'Sternglass is dealing with a very strong case'. With Three Mile Island not yet dead, Sternglass's account of his involvement in measuring and calculating emissions from that reactor, together with his claim that the fatalities from that accident can already be perceived . . . makes disturbing reading.

Ultimately the bomb and nuclear reactors are all part of the same process with facilities and funds shared by both. Ironically the connection was made abundantly clear for me by a woman who was all for Britain having the bomb but undecided about nuclear power. 'If you can show me that the plutonium from nuclear power stations is not essential for nuclear warheads I might be against such power stations on economic and safety grounds. Otherwise I would have to be for.' I personally could not give her that assurance.

Peter Bunyard

Lying for Profit

COVER UP: The facts they don't want you to know. Nicholas Hildyard, New English Library, £5.95.

How do people who continually contemplate the frightfulness of the present global situation, and who write about present and future disasters, actually feel and behave in their every day lives? Are Prophets of Doom like Goldsmith, or professional pessimists like Ronald Higgins of *The Seventh Enemy* (see *The New Ecologist* Jan/Feb 1979) broken men with haunted eyes whose every utterance rings with despair? The question was prompted by reading Nicholas Hildyard's *Cover Up,* a book by a young man, not designed to leave its readers in any doubt about the evils of commercial practices which, for reasons of profit, claim a daily or hourly toll of life at least as great (but uncountable because unadmitted) as those caused by road accidents. The answer of course is that Teddy Goldsmith and his colleagues, including Nicholas Hildyard, do not live in a state of perpetual gloom, and inspite of what they write and know, are alive and well and still at work on the doom business. Which is just as well, for if anything *is* to be changed it will be achieved by those able to see through the cosy platitudes and cynical assurances meted out to lull the public into a false belief that their government cares for them. Those who, inspite of seeing the horrors for what they are, yet believe that there are solutions and who, through their conviction, can galvanise the rest of us into awareness. What is wrong with *Cover Up* is not the carefully researched accounts of eight horrific cover-ups, but the lack of a concluding section with an analysis of the overall picture and proposals for immobilising the perpetrators. It's no use telling a paralysed man that his house is falling down unless you can offer him some suggestions for preventing it happening. In a sense *Cover Up* stops where the hard work begins. The facts that Hildyard has assembled are useful fuel, but in the end the value of the book must be measured by how much influence it will have on future events in this field.

It is not enough to say that we are all guilty because we condone these practices by demanding goods from industry — this is true, but trite. We know that *not* eating canned peaches from S. Africa will have precious little effect on their economy; the purpose of the campaign is to publicise the evils of apartheid and dent the image of S. Africa's white rulers. If this book can become a catalyst for the dissemination of knowledge leading to a greater public awareness of the practice of cover-up techniques, if it can get the depth of its immorality revealed and its dangers widely discussed, it will achieve much, for the greater the public *suspicion* the more difficult it will become for companies to get away with lies, and the quicker their ploys will be exposed.

When the head of the chemical division at Aldermaston, responsible for processing weapon grade plutonium said on the BBC that it was his opinion that an obsession with secrecy had possibly lowered the safety standards at Aldermaston, he was officially rebuked by the Ministry of Defence, an event that went unremarked by the public. But such events are symptoms that should be taken very seriously by citizens of a country that believes itself to be free and more-or-less honestly governed. In a new climate of suspicion such an event should become headline news; when the high-ups in a great commercial concern are caught lying it should be shouted from the roof tops; when a private citizen battles for years to get compensation from a company that has consistently sought to hide its responsibility for a death or damage to health, the company should be exposed. State controlled industries and multinationals worldwide are spending vast sums of money churning out misleading information based on bent research, with the sole intention of blinding the public to the truth about their hazardous activities. The list of offenders is long; Nicholas Hildyard deals with the nuclear industry; toxic waste disposal; pesticides and other chemicals; asbestos, radiation; lead in petrol and drugs. I hope his book will be widely read and that the information he has collected will quickly catch the eye of all concerned people, that the message spreads and generates the sort of fury and indignation against injustice, that can move mountains.

Ruth Lumley-Smith

Weeding Out Trivial and Worthless Research

ANIMALS IN RESEARCH: New Perspectives in Animal Experimentation. David Sperlinger, ed., John Wiley & Sons, £16.50.

This book's new perspectives refer to argumentation for reducing the number and suffering of laboratory animals that is considered more critical than any used before. In speaking of "the absurdity of attempts to praise or condemn animal experimentation as a whole," the editor recommends instead balanced, scientific assessments of the value to man (and other animals) of particular experiments in the hope of weeding out trivial or worthless research projects with resulting benefits to animals and to science.

Examining the goals of biomedical research, while no novel approach to the problem of animal experimentation, is certainly necessary for its solution. But when this recommendation comes from those who ignore or deny the religious and spiritual aspects of the problem, their narrow perspective can hardly lead to maximum benefits for man or beast or science. Without conscious recognition of the sacred, ethical arguments lack the depth and persuasion associated with the New Age of spiritual awakening we are entering. This is not to say that the scientific, philosophical, and animal welfare contributions to this book are without interest or value. It is indeed encouraging that all 16 contributors, many of whom are scientists, desire to reduce the exploitation of animals by biology and medicine.

One of the two papers I found most valuable is "The Fallacy of Animal Experimentation in Psychology" by Don Bannister of the MRC External Scientific Staff. It is a perceptive and eloquent elucidation of the fact that "countless animals who have died in psychological experiments have died not only cruelly, but in vain." Dr. Bannister's insight is diametrically opposed to the excessive objectivity of the life sciences; in pointing out how psychologists often lack psychological understanding of themselves, he exhorts them to experiment not *on,* but *with,* animals for the sake of all concerned, including psychology itself. This is to recognize that the close observation of suffering or maddened animals in order to illuminate the nature of man is poor science. Another excellent paper is *Why Knowledge Matters* by Mary Midgley, a philosopher. She begins by successfully contesting George Steiner's astonishing view that all truths, whether useful, trivial, or dangerous, are of equal value and should be pursued. Believing that the most significant scientific research is that which fulfills man's prime need for real understanding of life and the world, she shows why H.F. Harlow's cruel and unecessary experiments on monkeys represents science at its worst: "Destroying a creature emotionally." she asserts, "can never be the best way to understand its nature." Without offering any final solution to the problem of animal experimentation, Dr. Midgley would begin to solve it by eliminating first of all what is most cruel and disgraceful in science, and she ends with a plea for greater understanding of our continuity with non-human species.

With this and similar sentiments one can only agree, even if the book as a whole fails to satisfy. Its vision is too limited. It considers religious and spiritual insights and absolutist and extremist attitudes of the past as irrelevant to any serious treatment of animal experimentation today, and its basic premise is that *it will be necessary to continue* the kind of current animal research that is now yielding important benefits to man, even though some of the current uses of laboratory animals may involve over-use or misuse or trivial goals.

This vision reveals neither a sense of justice towards animals and their rights nor a sense of understanding of man's nature and destiny. The problem of animal experimentation goes, I believe, much deeper than this book allows: for some of us, it reaches right down to the essence of life and evolution. If one sees man engaged in a spiritual journey back to the Supreme Good, one also sees the biomedical benefits that may accrue to him on his way as of little account compared with the realization of his potentials for justice, love, compassion, mercy, and other godlike virtues. And how can man, or science, possibly become more spiritualized while continuing to believe that his physical existence is so important that sentient beings must still be tortured, maimed, or killed in order to maintain and prolong it in increasingly artificial ways? Many current biomedical goals are odious, unethical, and hostile to evolving life. Such goals, far more than the trivial and worthless, need to be assessed, but in their spiritual rather than scientific context.

Animals in Research is a serious attempt to right some of the terrible wrongs of modern science and on this ground alone deserves equally serious consideration. But in failing to relate man, animals, or science to spiritual evolution, its argument seems half-hearted and incomplete. The knowledge that life is a spiritual ascent towards self-transcendence guided by a divine ethic makes man unique, and it cannot be reconciled with toleration of injustice and cruelty to some living beings, regardless of possible benefits to others.

Catherine Roberts

The Necessity of Beauty

ART AS REVELATION. Frank Avray Wilson. Centaur Press, £8.75.

The most astonishing event in the 19th century was the enthusiastic credulity with which it accepted Darwin's theory of evolution as a doctrine explaining creation and natural development. It is almost the intellectual equivalent of the belief of some primitive people that the world rests on the back of an elephant, since it accounts for so small a part of the whole evolutionary process. The empirical British mind has discouraged imagination and is the prime obstance to seeing the world as in any way containing transcendental influences. Like the Snow Queen empirical science has frozen the heart and the mind, so that it may assure its dominance. Tired of the patter of tiny minds blowing up chance and natural selection to account for everything, a kind of mountebank's elixir of life, I have always searched for scientists who could offer something more adventurous and less mechanical.

It was therefore a great joy for me to read *Art as Revelation*, a work which has carried far further than I could my own unprovable predudices: that beauty is a major factor in evolution — Shakespeare proved that to be true in two lines of a sonnet:

> From fairest creatures we desire
> in increase
> That thereby beauty's rose might
> never die.

— that nature was preparing for the advent of humanity (now called the anthropic theory) in it prehuman evolution: that nature records somewhere a memory of all experience that can be used to guide further development, as we use memory ourselves. I have always been a fan of 'field' theories since I first read about them in the works of a Harvard anatomist; I do not see how anything else can account for the growth from the single cell to the completed embryo. Has not the universe been created and sustained by a similar integral discipline?

If we accept these assumptions which Frank Wilson has woven into a seductive synthesis, in what sense is art revelation? Because the peak aesthetic experience gives us a glimpse of the invisible reality that is the other half of existence: the mind and memory of nature out of which our own mind has emerged and which sustains it. Nature is an artist, though not always a successful one, experimenting in time with its timeless principles in search of elegant solutions to the problems of evolution and especially the humanisation of organisms. This humanisation includes both nature and man: that is, making the environment a suitable habitat for man so as to advance his development; and to make man's own organism an instrument of his spiritual development — is not the throat used both for eating and singing, the body for walking, running and dancing? Nature works so that the higher faculties integrate with the lower so that they become the means to greater human development.

I do not myself believe that science will ever provide ultimate explanations of existence; certainty would wreck the human adventure; but I do believe that as it advances it must inevitably encounter evidence that draws the imagination nearer to the truth. Frank Wilson, artist and biologist, explores the new clues provided by physics and biology to estimate how they tally with the intuitions of hyperaesthetic experiences. The result is a profound and stimulating work that draws art and science closer together and confounds those who have treated art as a threat to science. We begin to hope that scientific materialism is now being demolished by science itself. What a liberation that will be for Western civilisation.

The clue that Mr Wilson explores most optimistically is the quantum gap. Can it really be true that when subatomic particles vanish into the quantum gap often to re-emerge transformed into different particles that they have visited the invisible replica of creation in which nature stores her timeless memory and which provides an integrating 'field' controlling immediate creativity? A dazzling assumption that needs much investigation.

Is there any special sense in which this new-world view (which is what it is with much in common with Schweitzer's reverence for life) is of value to the ecological movement? Indeed there is. The whole movement must ultimately rest upon its basic assumption:— that evolution is guided by an aesthetic sense which is fundamental to the humanising process. All those who destroy beauty on behalf of efficiency and profit, or from any other dehumanising motive, are not aiding progress and evolution but opposing it. They are anti-progressives defending their destructive role with the antiquated notion of progress constructed from the simplistic assumptions of an out of date empirical science.

Robert Waller

Manufacturing Misinformation

THREE MILE ISLAND. Mark Stephens. Junction Books, £12.50, Paperback £4.95.

It is now over three years since the attention of the world was rivetted to a previously unknown town in Pennsylvania where, for more than a week, experts grappled with the problem of averting a major nuclear disaster involving the No. 2 reactor at Three Mile Island. Mark Stephens' book at last provides a readable and comprehensive account of the many faceted events unfolded during those days dealing, as it does, with both the technical and institutional factors operating before, during and in the aftermath of the accident. The author's involvement with the Public Information Task Force, which reported on the role of the media in portraying the accident, has placed him in an eminent position to produce such a work and the task has been executed with an all too rare combination of good journalistic style and technical accuracy.

Given his involvement with the Task Force it is not surprising that the major emphasis of the book is centred on the information flow, or lack of it, between the various bodies responsible for administering the accident. By adopting this approach the author produces a perceptive account of the confusion, lack of preparedness and inadequacy of institutions, from the Nuclear Regulatory Commission downwards, which were revealed by an accident which the experts said could never happen. More importantly the book gives some clear indications on how the 'Mind Set' of the nuclear industry, which played a major role in propagating and sustaining the accident, was built up by a reliance on the computer analysis of risk and safety factors.

The operation of this Mind Set was to lead to a staggering series of events. Having failed to recognise that vital cooling water was escaping through a jammed pressure release valve, operators turned off the flow of emergency cooling water to the reactor core. Instruments giving vital information on the state of the reactor were ignored because 'their training had told them that this could not happen'. Among this information was a recording of a 'pressure spike' in the containment dome and a core temperature calculation of 2,4000°F. The pressure spike represented a Hydrogen explosion and the temperature reading was almost 2,000° above normal operating levels. Both of these readings were clear indicators that the core was uncovered and was 'glowing in a bath of steam' as it began to melt down. Not until radiation alarms rang out was the situation recognised as serious and a 'general emergency' declared.

The author details how these and successive major events occurred and how the various regulatory bodies attempted to relay information to the media and civil authorities, commenting that, "some involved agencies tried to prevent it and others to hide it, even to the extent of lying to the press, and, through them the American people." This presentation of misinformation led to an atmosphere of apprehension, mistrust and outright fear amongst local inhabitants.

Whatever the intention of the agencies supplying information the outcome was a mass of conflicting and often contradictory reports on the status of the plant, radiation levels, and the likelhood of an evacuation. Indeed an important point made clear in the book was that prior to the accident there were no evacuation plans in existence. By the third day of the accident plans for five, ten and twenty miles had been hurriedly prepared and a State Governor, befuddled by two sets of conflicting expert advice, both emmanating from within the NRC, had advised the limited evacuation of pregnant women and children.

This apparent incompetence on the part of of the NRC Commissioners is perhaps one of the most striking points of the book. Only one had any technical competence, a fact which left the institution's executive powerless to give guidance in his absence. As Stephens comments "The NRC were less able to run TMI than the utility it was supposed to oversee." The NRC, acting as they were, on information that was 'often less accurate' than that available to the more determined press crews proved all but worthless during the early parts of the crisis earning itself the title of "a dinky little asshole agency" from one American Science Correspondent.

Mark Stephens' book is a well written indictment of an over confident industry, too quick to extoll its own virtues and issue categorical assurances about reactor safety, which subsequently left a small American community exposed to an intolerable level of uncertainty and fear as the industry's well rehearsed statements of reassurance crumbled when faced with the fact of TMI. The book is rich in biographical material relating to local residents, press and the various echelons of the nuclear industry. As such it has a strong human content and would perhaps be declared lacking in objectivity by the nuclear establishment.

This aside the technical information contained in the book is presented accurately and placed within a human context which portrays the real life impact of the accident. An impact which has left a widespread feeling of betrayal amongst the population of Pennsylvania and is summed up by the statement "We no longer trust, we no longer believe".

For anyone wishing to have a lively reconstruction of the unfolding of the accident at TMI, and the responses to it, this book is highly recommended.

Ian Welsh

Well-fielded

A YEAR IN THE LIFE OF A FIELD: Michael Allaby. David and Charles, £7.95.

The Reverend Gilbert White, with his Natural History of Selborne, was of course the father of all intimate studies of nature, and although Michael Allaby does not mention him in this very likeable book, it's my belief that when he was writing about the wildlife of his chosen field, White was not far from his mind. But of course it is two hundred years since White wrote his magical notes, and even if Cross Park has not changed much in the intervening period, methods of observation have. Thus we have in this handsomely produced book the benefit of photography both at ground level and from the air, as well as a wealth of field guides and other reference books of which the author has made good use.

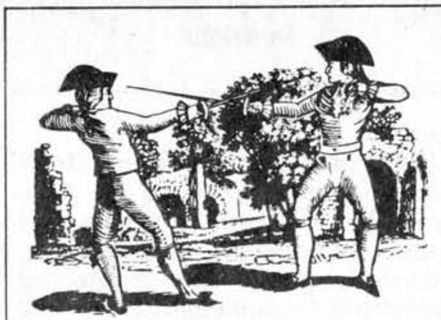
A Year in the Life of a Field is basically a month by month account of the farming cycle and the goings on among the flora and fauna at Cross Park, an eight and a half acre field on a Cornish farm. The author has used each chapter as the starting point for a series of light hearted and informative discourses on many aspects of Cornish history, customs, archaeology and legend. Except for rather too many reports about the weather beyond the Tamar, and a few general observations, this is very much a book about Cornwall. Thus in January, suitably beginning at the beginning, we learn something of the origins of the Cornish landscape, particularly in relation to granite, the moorstone which, more than any other single factor, has determined the agriculture, the architecture and the natural history of this field on the edge of Bodmin Moor. Neolithic man, the Bronze Age and the Iron Age together with Holy wells, enliven the month of February; in March we have a diverting description of geothermal energy (hot rocks), and so on through the year. Among digressions I enjoyed, were the revelation of what a prehistoric sheep looked like — neither white nor woolly — the lives and habits of bumble bees, and more unusually the cuckoo-bee of which I have to admit I had never before heard. The author apparently has great sympathy for the poor maligned slug, and describes with humour the trials and tribulations of the various small creatures who inhabit or stop over in his chosen field. I'm not sure that there isn't something a little patronising about his description of the Royal Cornwall Show, but perhaps that only proves how much this old institution has lost since it went commercial. Today, like the Olympic Games, it suffers from gigantism and no longer reflects Cornish farm life.

There are one or two surprises for someone who knows the area well, as for example, the observation that lapwings are not a common sight in these parts. Certainly I encounter flocks of these birds all the year round on the moor not two miles from Cross Park, and they breed in the marshes near by. Nor, I think, can the habit of using a sack as an apron, and to cover your head and shoulders in the rain, be an indication that the farmer could not afford a coat. As anyone who has worked on a farm knows, those good old corn bags were a great boon in wet weather, when you were picking spuds or driving livestock through the mud and rain. When you had finished your dirty job you flung the sacks off to drip over a beam in the barn, and went into the house clean and dry, causing no trouble to the farmer's wife, and keeping your coat clean for Sundays. It's not greater wealth that has changed the custom, I suspect, but the loss of those marvellous protective jute sacks, following the universal use of the combine harvester and corn silos.

Although this book gave me great pleasure I must take issue with its author over the way in which he presents and defends the Ministry of Agriculture's policy of badger gassing, and the dismissive manner in which he refers to those who are trying to get this policy reversed. Lord Zuckerman's report is based on the most questionable and unsubstantiated evidence, and whatever Michael Allaby may personally believe about this vexed question he should not refer to theories as facts, nor is it honest to write: 'I would not wish any human being to be infected with tuberculosis from milk . . .' thus implying that this is in some way the inevitable alternative to badger gassing. He knows full well that all herds are regularly tested and that any reactor is slaughtered, and furthermore that all milk is pasteurised or otherwise treated (worst luck) to eliminate the possibility of infection. So that *even if* the theory that badgers are the prime cause of bovine tuberculosis is proved, not gassing them will not lead to a single new case of TB in human beings. No other country in the world supports this idea or pursues this revolting and dotty policy.

That said let me end on a happier note. Had time allowed I would have liked to get a town dweller's view of this book, but I really have no reservations about it, and urge you to put it on your Christmas list as a splendid present for anyone interested in the changeless and mostly hidden life that pursues its busy, and largely private, course throughout our countryside.

Ruth Lumley-Smith



Letters

Sludge and Specialists

Dear Sir,

In November 1975, the *Bulletin of Atomic Scientists* commented: "To a a visitor from another planet it would seem incredible that human beings who are intelligent enough for space travel solve their problems of personal hygiene by putting their body wastes into public drinking water and then spend billions in futile efforts to restore the water to its original condition." One wonders how that same visitor would have reacted to Mr. Tilley's spirited, nay, abusive defence of this absurdity as "one of the world's most efficient and hygienic waste disposal systems in the world" (sic) and his rejection of basic rethinking in search of a more rational alternative as "ridiculously impractical if not impossible", "quite unrealistic", grossly irresponsible", etc.? (Letters, *Ecologist,* Vol. 11 No.4).

It happens that I live quite close to the River Avon which is Mr. Tilley's 'territory'. It is unfit to drink or to bathe in. I suspect that our hypothetical extraterrestrial visitor would think this "grossly irresponsible". He might apply a similar epithet to the pollution of our coastal waters, which apparently receive 10% of our sewage, half of it without any form or treatment (see 'The Unspeakable Beaches of Britain', *New Scientist,* 16th July 1981), so that where once families took healthy holidays, now they can only 'go through the motions'.

As to decentralisation to self-regulating communities being impossible without a military dictatorship, I should remind Mr. Tilley that physical force and starvation were used to move the population from the countryside; that catch-all laws such as the so-called 'Town and Country Planning Acts' are still used to keep them away; and that our government has contingency plans so that force will be used in an emergency, not to force people out of the cities, but to keep them in against their will! Is it just possible that Mr. Tilley's views on this subject are not shared by all?

Finally, I would like to stress that we have nothing but admiration for the highly qualified staffs of the National Water Authorities. What we would like to see (and so, I imagine, would many of they) is their talents used to develop and establish a system which is slightly less outdated and illogical. Our arguments do not need to be backed by insults: we can safely leave that to specialists like Mr. Tilley.

Yours faithfully,
Dr. D.S. Warren,
Food and Energy Research Centre,
Evesham,
Worcs.

Sludge and Convention

Dear Sir,

Whilst I do not recollect reading the article 'Money Down the Drain', it certainly succeeded in flushing out D.F. Tilley, the Senior Trade Effluent Officer of the Avon Division of the Severn-Trent Water Authority and a M.I.W.P.C. and a M.I.P.H.E. to boot.

Foaming with exclamation marks he attacks the authors of the article in question as having, "a positive obsession to conserve nitrogen"; he declares that certain proposals are "rediculously impractical if not impossible in western civilisations" and that to implement them, "would require a social revolution, a massive devolution of unprecedented scale, unacceptable to most of the population and surely only possible under a military dictatorship."

Mr. Tilley is beginning to get some idea of what the ecological movement is all about. He might like to consider that as a Nation we import roughly half our food, that even to achieve that our agriculture is totally dependent upon extraneous nitrogen inputs, that the production of artificial nitrogen fertiliser is an energy intensive process, that the fossil fuels are running out, that nuclear power is almost certainly both dangerous and impossibly expensive, that renewable energy sources will be hard pressed to meet but a small part of current energy demand and that most of the population will be less than madly enthusiastic about the prospect of chronic hunger never mind actual starvation.

Like the conventional thinker that he clearly is Mr. Tilley obviously thinks that our current economic problems are temporary and that a sustained 'upturn' is just round the corner. As an ecologist I think differently. I think that we are hell bent to destruction and that in the not too distant future we shall look back on 1981 as a year of great comparative affluence, in much the same way as the starving Third World must look at the 1981 that we complain about, right now. The reason why I think that the future is so bleak is because it is people who think like Mr. D. F. Tilley M.I.W.P.C., M.I.P.H.E that have been in charge of things for too long.

He may be right in saying that the sort of social revolution necessary, if it is to come about quickly enough to be effective within the time scale now left available, can only be possible under a military dictatorship. Ten years or so ago the democratic option still seemed possible but probably the exponential disaster curves are now rising so steeply that that option has already gone. Personally I am incapable of being so convinced that I am right to ever support the military dictatorship opinion and in any event ecologists are just not the right sort of people to be cast in the coup d'etat role. I do not therefore see any form of eco dictatorship. I do however predict dictatorship, a dictatorship that will arise conventionally from the political right as a reaction to the social unrest and eventual anarchy that will increasingly come about as the economic system continues to collapse, and in their several but cumulative ways it will be the Mr. D.F. Tilleys of this world who will have brought it all about.

Yours faithfully,
A.M. Whittaker, Ll.B.,
Founder Member of The Ecology Party,
Moretonhampstead,
Devon.

In Anger

Dear Sir,

Your article by Edward Goldsmith, Thermodynamics or Ecodynamics, is an anti-scientist tirade. It proceeds by setting up aunt-sallies in the form of selected quotations from individual authors without any mention that the scientific community is not a homogeneous body but is a lively forum continuously processing ideas and evidence.

The article is prefaced by a paragraph which begins "Scientists and philosphers — many of them sympathetic to the ecological movement — have . . .". Those scientists, like myself, who are sympathetic, think of themselves as a part of the movement, not sympathetic to someone else's movement.

The article itself is so full of utter misrepresentations of the second law of thermodynamics and what we think about it that we find it a great embarrassment. It is clear that Goldsmith does not understand the fundamental principle of a physicist's thinking: thus, when he talks about such concepts as a closed system the scientist does not necessarily believe that such systems exist anywhere, but merely that in certain situations a system may for practical purposes be treated for a short time as if it were closed. Until that is grasped no-one has the right to criticise a physical theory, still less to criticise those who have been able to be extremely creative by the use of it.

After all, engines, which have been very successfully designed by the use of thermodynamics, are merely the means invented by one of the highest life forms to break out of the limits set by the mechanics of biology for the production and transformation of energy. It is silly to talk as if the resource scarcity, which has come about as a result of the invention of engines, and is undesirable, is the result of a scientific error of some sort. The error is political and social, and not in thermodynamics. The error may lie in our inability to give our forsight priority over short term opportunities, because the distant future is less certain, and forsight may even be mainly wisdom after a previous event.

If policy makers (and biologists, even ecologists), misinterpret a very good theory of thermodynamics, that theory is not the origin of our predicament.

Physicists are not concerned with metaphysical issues such as whether atoms or tables and chairs have greater reality (what is the criterion for the greatness of a reality?). Goldsmith seems to imagine that we physical scientists can't see the obvious, presumably because he doesn't understand what we are talking about (which is what seems to be the case from his article).

As an example of his factually incorrect statements we may cite "The biosphere is a closed system as far as materials go". The weather and geological turmoil are continuously making new minerals available to life forms, and evolution has proceeded on the basis of exploiting this. Contrary to his implications the tropical rain forest actually gets a great many salts in the rain, and it obtains considerable outside material from the bodies of insects and birds which fly into it and die there. What is more, it is continuously changing particularly at its edges, by accumulation of windblown material or tidal deposits.

After citing Lovelock's Gaia theme — which I find a fascinating and useful concept, and which Goldsmith can't resist accepting, (although there is no need whatever to declare a belief or otherwise in order to find the concept useful) Goldsmith asks "why our scientists so stubbornly refuse to face both the theoretical and empirical evidence against the applicability of the entropy law to the world of living things".

The answer is clear to me: they faced it long before Goldsmith even considered the issue. And it simply will not do to find writings of some mongrel scientist/-philosopher asserting otherwise. The article is a tirade about a non-issue which discredits the environmentalist anti-growth movement if only by association!

Yours, in anger that the side has been let down,

Prof. R.S. Scorer,
Imperial College of Science and Technology.
Queen's Gate,
London.

Classified

MISCELLANEOUS

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