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NEED FOR ORGANO-MINERAL FERTILIZER IN TROPICAL AGRICULTURE • ENERGY AND ECONOMIC MYTHS

DO WE NEED A MINISTER OF NUTRITION ?
by Joanne Bower

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This month's cover: Elizabeth Moya

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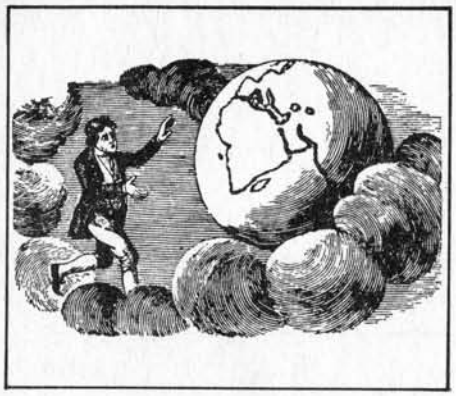

Heads You Win, Tails I Lose!

Dr. John Howells, Director of the Institute of Family Psychiatry, has stated quite seriously, that the mother is not necessarily the best person to look after her child. Such an apparently lunatic statement on the part of a so-called 'expert' can only be regarded as a rationalisation of his preconceived decision to encourage the further institutionalisation of child-rearing.

The truth is that we are faced with a very unpleasant choice. According to Howells, at least two children are killed every day in the United Kingdom by their parents and many more are maimed in body and mind. Do we allow this to continue in this way, or do we put them in institutions? The trouble is, that both courses of action must lead to disastrous results. For, contrary to what Dr. Howells says, to bring up children in institutions is very unsatisfactory and, considerably increases their chances of becoming emotionally unstable, delinquent, schizophrenic, etc.

Many experts are now seriously suggesting that it is better to feed babies on bottled milk. The reasons for such an equally lunatic thesis is that, in many cases, human milk is contaminated with D.D.T., Aldrin, Dieldrin etc., to which babies are considerably more sensitive than adults, and whose ingestion could lead, among other things, to liver cancer in later life. (In Guatemala, levels of a hundred times higher than those considered acceptable by W.H.O. have been recorded in human milk.) Once more, we are faced with a very unpleasant choice, for cow's milk is not a substitute for human milk, and we know that babies brought up on it will have a greater tendency to obesity and reduced resistance to infectious disease.

Professor Kenneth Mellanby, a famous Government 'expert' specialising in underplaying ecological problems, seriously advocates the continuance of present day agricultural practices: artificial fertilisers, pesticides, the grubbing-up of hedgerows, monoculture and the lot. The arguments he provides to demonstrate their harmlessness simply illustrate the human capacity for rationalisation. Professor Mellanby has decided in advance that all these things must be indulged in, partly so as not to antagonise people, partly too, so as, he thinks, to feed the massive population of this country from an ever shrinking agricultural base, with prospects of importing food from abroad becoming ever less favourable. Contrary to what Professor Mellanby says, however, modern agriculture is hideously destructive. In the last fifty years, in fact, there has probably been more soil deterioration than during the whole of man's previous history.

Drs. Reed and Tolley go still further, and seriously suggest that human faeces should be put on our menu. It is apparently "not unpalatable after homogenisation followed by steam sterilisation, oven drying and final cooking". Are they taking the micky out of us? Apparently not. World Food prospects are so bad that it may in fact be our only means of avoiding starvation. Once more, we have an unpleasant choice on our hands: – Eat human excrement or starve – and as the World food situation deteriorates, it may well be recycled human bodies, as in "Soylent Green", that we shall have to eat to keep alive. Yet once more we are faced with an unpleasant choice which is basically: – eat today and starve tomorrow, or starve today and eat tomorrow.

Politicians and economists are unanimous in advocating containerisation in the Port of London. We know that this must cause unemployment among dockers. Why then must it be done? The answer is that if we don't, business will simply shift to Rotterdam. Unemployment is thus inevitable, whatever, it appears, we do. Indeed, it looks as if we simply cannot win.

In Alsace, experts recently countenanced the destruction of a very beautiful and ancient forest to make way for a vast factory mainly involved in producing a yellow dye to colour the yolks of battery-produced eggs. The justification for this vandalism was that jobs had to be provided for the local people. As it happens, this was untrue and several hundred Turks had to be imported. Even if it was, however, this enterprise would not have solved any problem, for to provide employment it was necessary to destroy these very valuable woods – quite apart from accepting the inevitable pollution and resource depletion which this large enterprise must cause.

The choice, however, appeared to be at the time between unemployment and ecological disruption. What is more, in the near future, we may have to make still more unpleasant choices of this sort. It may be armaments rather than yellow dye factories next time, and in order to maintain the necessary level of employment,


NOW LOOK WHAT A FINE MESS YOU HAVE GOT ME INTO ..... URRH!!

we may one day have to make use of these armaments and engage in full-scale war. This is undoubtedly the way to maintain unemployment at the very lowest level.

Why, might we ask, are we confronted with such very unpleasant choices? To answer this question we must look back into our past.

Man once lived in small tribal groups. He earned his living either by hunting and gathering, or by 'slash and burn' agriculture. We have been brainwashed into believing, contrary to all the evidence, that such people were poor, miserable and barbarous, and that, as a result of the developments of the last ten thousand years, and in particular, of the last one hundred and fifty, (since we have seriously gone in for industry) we have become affluent, happy and civilised – contrary to all the evidence.

It might be pointed out, however, that these small tribal groups were not called upon to make the unpleasant choices which we have to make.

Indeed, in those days, there was no need for childcare institutions because parents did not batter and kill their children. In fact, such aberrant behaviour is unheard of among the remaining traditional societies of today, and only occurs in a very degenerate one such as ours.

Nor did they have to feed their babies on bottled milk, because they were not mad enough to pollute human milk with toxic agro-chemicals, simply in order to obtain slight short-term increases in crop-yields.

Also, because they kept their population under control and preserved the fertility of their land by means of ecologically sound, 'slash-and-burn' agricultural techniques, they could afford to eat greater delicacies than human excrement.

They did not have to worry about unemployment either, since there was, in fact, no employment. Our ancestors worked in their family groups to satisfy, usually in highly propitious conditions, their biological and social needs.

The reason we are faced with these 'Heads you Win, Tails I Lose' situations, is that we have 'progressed' so radically from this initial and theoretically optimum situation – the product of millions of years of Evolutionary Research and Development.

The result is that we find ourselves in an increasingly aberrant one in which the problems we face become increasingly insoluble. *What our 'experts' teach us to regard as a solution is, in fact, simply a means of exchanging one problem for another (usually more serious) one, which is perhaps not so easily discernible.*

Once we realise this unpalatable fact, it becomes apparent that, contrary to what we have been told by our 'experts', we are not, in each of these cases, faced with a choice between two alternatives, for *there is always a third course open to us:*

Indeed, we can set about, systematically, to modify the socio-economic conditions we live in, so that the choices open to us become progressively less disagreeable. This means methodically recreating a physical and social environment which ever more closely approximates to that in which our palaeolithic forbears once lived. We can clearly never reconstitute such a situation, but we can copy its more salient features. Here is the ultimate challenge to human ingenuity. Here too, lies the only course upon which we can embark which, unlike that proposed by our 'experts' does not involve an all-out war against the evolutionary forces which brought us into being.

Edward Goldsmith

An Ecological Calendar Completed

Present Calendar Dates		No. of Days in new months		Celtic month tree names
December 23rd	(New Year's Day)	29		Beth (Rowan)
January 21st		30		Luis (Rowan)
February 21st		29		Nion (Ash)
March 21st	Equinox	1		
March 22nd		30		Fearn (Alder)
April 21st		29		Saille (Willow)
May 20th		30		Vath (Hawthorn)
June 19th	'Holy Days'	3		
June 22nd	Solstice	1		
June 23rd		29		Duir (Oak)
July 22nd		30		Tinne (Holly)
August 21st		29		Coll (Hazel)
September 19th	'Holy Days'	4		
September 23rd	Equinox	1		
September 24th		30		Muin (Vine)
October 24th		29	*	Gort (Ivy)
November 22nd		30		Ruis (Elder)
December 22nd	Solstice	1		
		365		

* The 13th month in the Celtic Calendar was Ngetal (Reed), between Gort and Ruis)

We apologise to Richard Carder and to our readers for the omission of the first three months of the year in his calendar in the May issue. Perhaps hibernation was on our minds.

Need for Organo-Mineral Fertilizer in Tropical Agriculture

by S. P. Dhua

The wholesale transference of agricultural methods, appropriate to countries with a temperate climate, to tropical areas where conditions are very different, has often led to disappointing yields and also to widespread soil deterioration. In this article Dr. Dhua deals convincingly with one aspect of this problem, and shows that the application of artificial fertilizers to tropical soils is not sufficient to obtain sustainable yields, unless organic matter is also added.

1. Introduction

The need for organic matter in tropical agriculture for maintaining steady agricultural productivity of the land is well recognised. In the context of acute fertilizer shortage in India and elsewhere, which is also likely to continue for a number of years to come, the need for utilisation of organic wastes for agricultural production has assumed a new dimension and has come under serious discussion at various international forums recently. Although some schemes for the development of local manurial resources like urban and rural composting, sewage and sludge utilisation, methane gas plant, green manuring, etc. have been in operation for some time, these have not made any substantial headway as compared to the vast potentiality and enormous scope for production of organic manures. While no serious and systematic attempt has been made in India to use the organic wastes for recycling to the soil for building up and maintaining soil fertility and thereby achieving sustained productivity, quite a lot has been done in this regard in other countries. An Indian delegation to China in 1956 reported on the extensive use of organics as follows:

> "About 85 per cent of the total cultivated area in China is manured through organic manures such as night-soil, stable manure, compost, green manure crops, mud from the bottom of the canals and ponds rich in organic matter, and through chemical fertilizers."

Nature's organic cycle could be described briefly as follows: Crops are produced from the soil which remove nutrients and other elements. The crops are consumed by living beings and certain quantities of the nutrients are retained in their bodies while the rest are excreted. To complete the cycle the excreted materials as well as bodies of living organisms must go back to the soil to maintain the equilibrium. Modern civilization has caused a break in the cycle. While the excreta and other organic wastes are recycled back to the soil in many temperate countries, the same is not being done in tropical countries including India where the need happens to be much greater. As a result, therefore, there seems to be a steady decline of soil fertility and therefore of productivity.

Since a hot humid climate does not permit building up of organic matter to an appreciable level, a quick turn-over of organic matter is essential for our soils for maintaining soil fertility and thereby ensuring steady crop production. *It is an established fact that there is a steady reduction of organic matter in the soil if only fertilizers are used year after year without proportionate supplementation with organic manures*[1]. *Therefore, any system of agriculture that does not ensure maintenance and build-up of soil organic matter is likely to lead to the fast deterioration of soil health particularly in humid tropical agro-climatic conditions.*

2. Strategy for Organic Fertilizers

Although depletion of soil organic matter may not be a serious problem in the temperate countries, adequate attention is paid in Central and Western Europe to maintain the organic matter status of the soil through regular dressing with farmyard manure and compost. The practice of recycling organic wastes is of considerable importance in some of the developed countries of the world notably in China and Japan. We in the humid tropics, with soils containing 5 to 10 times less organic matter, seem to be least concerned about it where we should be even more concerned.

3. The Basic Issue

An average temperate soil is 5 to 10 times as rich in organic matter content as the average soil of the humid tropics viz. India. High temperature and high humidity in our country — for that matter in the humid tropical countries in general — encourage vigorous bacterial growth and activity. In consequence the decomposition of the organic matter in the soil is extremely rapid. On the contrary, in the temperate countries, due to low temperature conditions, the bacterial activity is much smaller. Hence, the organic matter in the soil is not subjected to rapid decomposition, with the result

that the organic matter content there is very high.

The importance of maintaining the high organic content of the soil has been viewed by some from only one angle, namely its favourable influence on the physical properties of soil, i.e. on the improvement of its structure, the enhancement of its water holding capacity and high base exchange properties. *The other and the more fundamental aspect, which is often not duly recognised, is the role of organic matter in supplementing plant nutrition through the steady supply of all the essential elements required for optimum crop growth in balanced quantities including that of carbon.*

It is known to farmers that good crop responces are obtained from the application of organic manures and adequate attention has been paid to the importance of NPK and some other trace elements, as nutrients, little attention has been paid to that of carbon as a nutrient, though this has been well established by a number of scientists. Borasio[2] among others suggested that since plants contain 40, 164, 52 and 308 times more carbon than nitrogen, phosphorus, potassium and calcium respectively, atmospheric carbon must be supplemented through the application of carbon derived from organic matter. The available literature on the subject, indicates that the carbon dioxide concentration of the soil is increased two to three fold by the use of manures on the surface of the soil[3].

Yurbitsky[4], a Soviet scientist, used cucumber and sugar beet plants in his experiments and found that the favourable influence of manure on their cultivation was partially due to increased uptake of carbon dioxide by the plant.

Reinau[5] proposed a hypothesis that carbon dioxide originating in the soil during the decay of organic matter is an important factor causing higher yields of close-standing crops. The close-standing crops cover the soil by spreading their leaves, thereby trapping most of the carbon dioxide released from the soil into the micro-atmosphere due to the decomposition of the soil organic matter by the bacterial activity.

Kuzin and Merenova[6] confirmed Reinau's hypothesis[5] and established that plants take up carbon from organic manures through both leaves and roots. In their experiments they used wheat plants supplied with organic manures containing tagged 14_C. They experimented over the entire period of growth of the plants and found that they rapidly absorbed carbon dioxide from the manures. They also found that the rate of growth of the plants and the uptake of carbon were highly correlated. The uptake and utilization of carbon as well as the growth of the plants was high in the earlier stages when the concentration of carbon dioxide in the soil was high. D'Yakonova[7] confirmed that the cropped soils supplied more than 50 per cent of the carbon dioxide assimilated by the standing crops.

Any system of agriculture that does not ensure maintenance and build up of soil organic matter is likely to lead to fast deterioration of soil health

There is also adequate scientific evidence to prove that carbon dioxide is also fixed by the plant roots in the dark through a process known as dark fixation of CO_2. [8, 9, 10, 11]. By the addition of organic matter in the soil therefore two processes are helped – intake of $C0_2$ by the plants through the process of photosynthesis and the dark fixation of $C0_2$ through the plant roots. All these findings lead to the obvious conclusion that organic manure is a very important source of carbon to growing plants besides supplying NPK and a host of other trace elements in balanced quantities.

The highly mineralised soils containing lower quantities of soil organic matter obviously would generate proportionately less carbon dioxide in the micro-atmosphere for ultimate consumption by the plants. In the temperate countries, the crop response to nitrogen application and its percentage utilization is distinctly higher as compared to those under humid tropical conditions. For balanced growth crop plants also need nutrients in balanced quantities. To consume effectively one unit of nitrogen, the plant would need 40 units of carbon. This carbon has to come from either the atmospheric $C0_2$ or from the $C0_2$ generated in the soil due to the decomposition of soil organic matter.

In the humid tropics there is distinctly lower percentage utilisation of nitrogen applied in the form of fertilizer and frequently adverse effects of nitrogen application at a higher level is noticed. It is well known that nitrogen increases the proportion of protoplasm in the plant cells. If the supply of nitrogenous substances to any actively growing vegetative part is abundant relative to the supply of carbohydrates, a large quantity of protoplasm will be formed relative to the amount of cell-wall material constructed. *The resulting cells will ultimately be large and thin-walled and hence weak.* Such cells will also contain an abundance of protoplasm and water thereby reducing the osmotic pressure of the cell-sap and increasing the loss of water through transpiration because of the increase in the surface area. Ultimately the tissues which would be formed mostly or entirely of such large thin-walled cells will be soft, succulent, delicate and vulnerable to many adverse effects. Only a small proportion of mechanical tissues, which give strength to the plants, can develop under such metabolic conditions. Plants growing under such imbalanced nutritional conditions would be relatively unfruitful and extremely susceptible

TABLE – 1

Effect of land use on soil nutrient status

(After Agboola *et al*, 1974)

	FIELD I Only chemical fertilizers (10 years)				FIELD II Organic matter + chemical fertilizers (19 years)			
	pH	Organic matter %	Available P (ppm)	Exchangeable K (ppm)	pH	Organic matter %	Available P (ppm)	Exchangeable K (ppm)
Orlginal Value	6.8	3.20	44.00	350.00	6.8	3.20	44.00	250.00
Changed by cropping	5.4	0.93	20.98	37.98	6.0	1.77	52.71	92.10

to drought, diseases and pest attacks.

On the contrary, if there are relatively more carbohydrate substances than nitrogenous ones in the plant, there would be proportionately more cell-wall structures and less protoplasm would be formed. The resulting cells would be small and thick-walled and osmotic pressure of the cell-sap would increase considerably due to the presence in it of more soluble sugars. The tissues composed largely of such cells would be usually compact and hardy. *Such plants would be more fruitful and considerably more resistant to drought, pests and diseases. The vegetables grown under such conditions would also taste sweeter because of the higher content of sugars and carbohydrate materials as compared to protein and water.*

4. The Problems of Using Fertilizers Alone and the Solution

The production capacity of soils inherently low in organic matter content is likely to be affected adversely with continuous use of chemical fertilizers without a proper organic complement. Most of the humid tropical soils, as indicated earlier, are poor in organic matter on account of high temperature and high precipitation encouraging rapid microbial growth, decomposing the organic matter in the soil.

Under the tropical soil conditions of Western Nigeria, long-term experiments carried out over a period of 19 years indicate a clear trend (Table – 1) of beneficial effects from the use of organic manure on soil fertility as well as the damaging effects of using chemical fertilizers only.[1]

The data clearly indicate that the field which received only chemical fertilizers lost about 75 per cent of its original organic matter content after only 10 years of cropping while the field receiving a combination of organic manures and chemical fertilizers lost only 50 per cent after 19 years of continuous cropping.

The significant reduction in soil organic matter in the field receiving only chemical fertilizers is explained by the mobilization of carbon of the soil organic matter by bacteria in the presence of nitrogen supplied through chemical fertilizers.

The field receiving a combination of organic matter and chemical fertilizer had developed less acidity than the field receiving chemical fertilizers due to the buffering-effects of organic matter. The available phosphorus and potash was also high in the fields receiving a combination of manures and fertilizers as compared with the one receiving only fertilizers.

Long term experiments on wheat carried out in the U.S.A.[12] over a period of 60 years confirms the findings of Agboola et al.[1] The results show very clearly that manures and fertilizers when used singly but judiciously, produced almost similar yields which were significantly higher than those obtained in unfertilized plots. A combined application of manures and fertilizers, however, in calculated proportions, resulted in a positive interaction, thereby producing significantly higher yields than either the manure treated plot or the fertilizer treated plot (Fig. 1.).

The facts emerging from the above experiments clearly indicate that a combined application of organic manures and fertilizers produce significantly higher crop yields than either organic manures or chemical fertilizers used singly. The results further indicate the long-term beneficial effects of organic manures in conserving soil fertility, thereby ensuring steady soil productivity. The efficiencies of chemical fertilizers could therefore be significantly improved through their combined use with organic manures. Long-term experiments carried out in India also confirm the above findings[13].

5. Increased Efficiency of Chemical Fertilizers in Presence of Organic Manures

It is common knowledge that the percentage utilization of plant nutrients is significantly low under tropical soil and climatic conditions as compared to those under temperate soil conditions. The efficiency of the chemical fertilizers, i.e. the percentage uptake and utilization of N, $P_2 0_5$ and $K_2 0$ improves significantly when used in combination with organic manures.

Nutrient uptake studies employing precise radio tracer techniques have shown that it varies from nutrient to nutrient, crop to crop, soil to soil, source of fertilizer and also management practices. For example, the percentage utilisation of nitrogen varies from 30 to 50, although recoveries of nitrogen above 50 may be expected in a few cases under excellent management conditions[14]. Therefore, more than 50 to 70 per cent of the total nitrogen applied in the form of fertilizers is wasted. So far as phosphorus is concerned only 10 to 20 per cent of the phosphorus applied in the form of fertilizers is utilised by the first crop. Similarly, only a small proportion of the total potash applied to the soil is utilised by the crop.

The lower utilization of these major nutrients particularly of nitrogen could be related to possible inadequate availability of other nutrients in balanced quantities particularly of carbon from the soil which could only be overcome through the use of organic matter on the soil. The nutrient losses from inorganic fertilizers could also be prevented substantially if organic manures are added in combination. For example, the loss of nitrogen by leaching and volatalization which accounts for about 42 to 47 per cent, can be minimised by its use in conjunction with organic manures[15]. The organic matter also helps in reducing the nitrogen loss by retaining it in the colloidal-exchange-complex of the organic matter and also partly by temporary biological immobilisation[16, 17].

With respect to the phosphatic fertilizers, it is an established fact that very limited applied phosphorus is available to the crops because of formation of an insoluble complex on application. Experimental data prove conclusively that the loss of phosphorus from the phosphatic fertilizers, primarily due to its fixation in the soil could be minimised by its incorporation in the organic matter. Also the response to phosphorus application is considerably increased when phosphates are used in conjunction with organic manures[1, 15]. Even rock phosphate when used in conjunction with organic manures results in significantly higher use of phosphorus by crop plants. Organic manures also reduce the rate of loss of exchangeable potassium and make it available to the plant during the entire growing period.

6. Logical Need for an Organo-Mineral Complex Fertilizer.

Agronomically, therefore, what is needed is a combined use of organic manures and chemical fertilizer or an organo-mineral-complex. Such an organo-mineral-complex would help to remove the shortcomings of organic manures on the one hand and chemical fertilizer on the other.

In view of the steady deterioration of soil productivity of humid tropical soils with continuous and increased use of only chemical fertilizers, really serious thinking is required to work out an agricultural strategy to utilise organic wastes as fertilizers on a large scale. By way of incorporation of inorganic nutrients to organic manures, the efficiency and the rate of utilisation as well as residual effect of plant nutrients or organic and inorganic fertilizers, the soil fertility and crop production is greatly improved. This is very significant from economic considerations of the fertilizer users – the farmers – who can have better input-output ratio from fertilizer use. For the humid tropics, therefore, an organo-mineral-fertilizer would not only supply all the nutrients required in desired proportions to crop plants but would also maintain the soil productivity because of the organic base. On account of the higher contents of nitrogen and phosphorus, the material could be more economically transported longer distances for marketing and use. Not only the high nutrient value of the organo-mineral-complex would make it acceptable to users but far more important is the ecological balance that it would maintain for sustained agricultural productivity of the soil which is highly desirable for a scientific proposition.

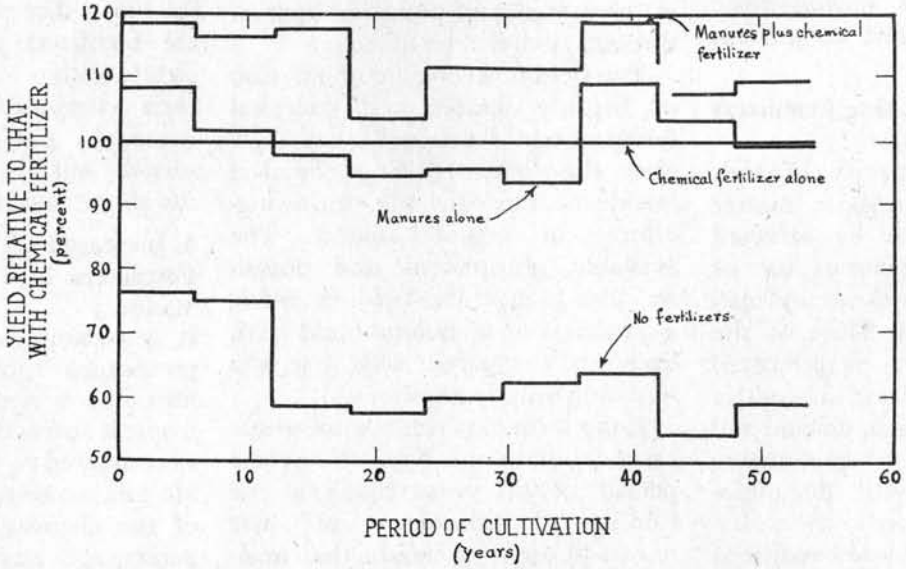

FIG.I. RELATIVE YIELDS OF WINTER WHEAT WITH DIFF -ERENT FERTILIZER TREATMENTS.

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Do we need a Minister of Nutrition?

by Joanne Bower

There is every reason to suppose that the British Public is not adequately protected against the dangers arising from consuming foods produced industrially with the aid of all sorts of agro-chemicals, and processed into convenience-foods with the aid of further chemical 'additives'. The health of the Nation is at stake and, argues Joanne Bower, a Ministry of Nutrition should be created to safeguard it.

The first issue of the Ecologist[1] contained an admirably argued and logically presented case for a combined Ministry of Health and Land Use by the late Professor Lindsay Robb. This plea has fallen on the deaf ears of successive Governments. Had it been otherwise, and given a dedicated Minister, it might not be unreasonable to suppose that agriculture would have been spared its present desperate crisis. We might even now have a farming community practising good husbandry, producing wholesome food for a healthier population and ensuring the long-term fertility of the soil. Lindsay Robb urged a recognition by the medical profession of the basic connection between nutrition and health – a connection that is being increasingly stressed by the experts. But to this hour few doctors, unless faced with obvious symptoms of food poisoning or a clear case of a deficiency disease, seem to enquire into the eating habits of their patients. Probably the poor fellows know only too well how difficult it is in these affluent days to obtain good food, and have themselves too often been dependent on the hospital canteen with its white bread, battery eggs, sausages, over-cooked vegetables, intensive pig-meat and broiler chicken containing who knows what in the way of residues from feed additives, hormones, vaccines and drugs. Dr. Roger J. Williams, nutritionist, is one of the many who affirm that the nutritional micro-environment of our body-cells is crucially important to our health, and that deficiencies in this environment constitute a major cause of disease. He suggests that in orthodox medicine physicians are actually taught to think of this as a restrictive principle, and to assume that the majority of illnesses with which they have to deal have virtually no connection with nutrition at all.[2]

The fact is that, in spite of the touching faith of the general public that "someone" is looking after us, the fragmentation of these matters between Government departments leaves the fundamental relationship between our food production methods and our health no-one's direct responsibility. The Minister for Consumer Affairs is involved with prices: values are not her province. The attitude of the Minister of Agriculture, Fisheries and Food was deftly summarised by Mr Anthony Stodart in the last Government: when questioned about possible health hazards in chicken, he replied that public health was not a matter for his department:[3] but food comes under that department, not under the Department of Health.

Certainly we have an Agricultural Research Council, a Medical Research Council, and numerous Governmental committees, but the fact that millions of pounds of public expenditure on hospitals and drugs might be saved if we were properly fed seems of little interest to any of these. As long ago as 1965 the Annual Report of the National Food Survey Committee did announce that, concerning the shift in the spending pattern from cheaper to dearer types of foods:

> "Much of the gain was due to increased purchases of convenience foods, and contributed very little to the energy value and nutrient content of household food consumption".[4]

But there appears to be no record of any attempt by any Minister to discourage the growth industry of convenience foods.

Lindsay Robb made the point that agriculture almost all over the world is based on producing the largest quantity at the lowest cost. With food as with all else, we are not likely to get something for nothing. Since his article was written, we have had embarrassing food surpluses throughout the developed world, concurrent with overweight

populations, animal health more and more dependent on vaccines, antibiotics and other drugs, and the steady onward march of degenerative disease in humans, with hospital cases in England and Wales up by one million in 1972 compared with ten years previously.

Cases of straightforward food poisoning, usually by salmonella, have most frequently been traced to meat and poultry, even to meat from animals grazed on pasture fertilised by manure from intensive poultry units.

Antibiotics and Additives

But what of the more insidious effects of the poisons we now ingest daily in almost all our foods, from the sprays used so prodigally on the seed, the soil, the growing crops and ripening fruit, and the residues in meat and eggs? There are also big question marks around the relationship between food and mental illness and diseases of the central nervous system. Evidence strongly suggests that environmental factors, particularly foods and their chemical concomitants, may be just as important as purely emotional stress in the production of anxiety states, depression and functional disease.[5] Symptoms of psychiatric abnormality have been traced to organophosphoros insecticides,[6] and mercurial seed dressings have caused terrible suffering and death.

Enough is certainly known for a conscientious Minister of Nutrition to bar many hazardous substances. Stilboestrol, a hormone known to produce second generation cancer, and suspected of hastening the onset of all types of cardiovascular problem,[6] is already banned for use in livestock in other countries of the EEC. After much pressure here, a Committee was set up to enquire into its effects. As a result, its use for injection is now controlled, but it is still permitted as a feed additive and implant. Other hormones and arsenicals in animal feeds are also banned in the EEC, but pharmaceutical interests are exerting great pressure on the Minister of Agriculture to ensure that Britain is exempted from this ruling, or that it be withdrawn altogether. Arsenic, it is claimed, "in its pentavalent form is almost non-toxic to humanbeings". Almost. But a medical consultant has this to say:

"The use of toxic chemicals such as arsenical compounds as feed additives for livestock intended for human consumption must be abhorrent to most people. The amount of arsenic absorbed by consumers of the meats in question may be relatively small – probably too small to produce obvious systems . . . They may not produce apparent adverse effects in the short term, but the long term effects are as yet unknown. It is probable that they would produce symptoms of chronic ill-health which would be difficult to diagnose. In such circumstances, I feel that a claim that arsenic in its pentavalent form is harmless to man would be difficult to substantiate".[7]

The case against the wholesale use of antibiotics for growth promotion was finally established in the Swann Report in 1969,[8] although warnings had been issued long before. By 1971 some control was exercised. Penicillin and the tetracyclines were only to be available as additives in feed for retail sale on prescription by a veterinary surgeon. What happens in the vertically integrated concerns which mix their own feed (and employ their own vets) we do not know; nor to what extent the limits recommended on antibiotics for medicinal use are exceeded: there is no inspection of carcasses for antibiotic and other residues. There is also a considerable antibiotic black market which the Government appears to accept as uncontrollable. Certain feed additives are supposed to be withdrawn a specified time before slaughter, but there is no check on this, and it is generally accepted that the regulation is ignored. Indeed, until 1974 there was no requirement that additives should be declared on the feed container, so farmers did not even know what they were giving their stock (consumers still do not know what their meat was fed on). One additive, long used for force-moulting poultry and in pig feed was withdrawn a little time ago on the discovery that when fed to pregnant sows it caused deformed piglets. Another, widely used in pig, poultry and calf feeds, was withdrawn after experiments associated it with tumours in rats. This created no publicity beyond short paragraphs in the farming press, but possible parallels with thalidomide have suggested themselves.

Poultry manure from battery houses is processed into animal feed, a short cut in the natural cycle which true farmers deplore. Despite official blessing, the fact that there is no overt effect on animals given such feed, does not prove that no harm is being done. As Elspeth Huxley pointed out in *Brave New Victuals* our livestock have short lives. We eat the very young, and the cumulative effect on the consumer may not be perceived until the second or third generation. More serious is the practice of processing broiler

litter for feed: this contains arsenicals, antibiotics, growth promoters, coccidiostats, wood preservatives (chlorophenols) etc. Although the direct addition of these to animal feed would now have to be declared, the indirect addition made in this way, is overlooked.

PESTICIDES AND FUNGI

The indoor rearing of stock in conditions of high density in a warm, humid atmosphere, has not only meant a greatly increased risk of disease, but necessitates drastic methods of insect control. Vapona strips, about which there has been so much controversy, now carry a warning:

"Do not use in larders or cupboards where food is stored".

but they *are* widely used in intensive units where our meat and eggs are produced. Another method of controlling insects actually states in its advertising copy:

"Flies are deadly. They can be – and are being – killed by chemical sprays and nerve gases. These chemicals pollute foods and even your staff – as Government reports state. They also allow dead bodies to fall into and contaminate foods".*

Not only may such poisons be inhaled by housed animals or deposited in their food but they enter the effluent. In poultry units, especially, further poisons are employed against flies and rodents which multiply in the dropping pits or litter, and where this is deposited on the land such poisons can find their way into vegetables and crops. It is not surprising that human health, in particular that of the unborn foetus, which is extremely vulnerable to chemical pollutants should be affected in all sorts of ways.

A further source of poisoning is in grain which has been insufficiently cleaned and dried. Bacterial and fungal poisoning of grain produces a disease known as mycotoxicosis. It appears that, the effects on those eating the grain are very alarming indeed, as mycotoxins attack the living cells, beginning with the central nervous system; they appear to damage all parts of the body and pave the way for a variety of diseases, including beriberi, pellagra, leprosy, tuberculosis, liver cancer and heart failure.[9]

In 1967 a Symposium arranged by Dr G. Lindeberg, of the Agricultural College of Norway, discussed the problem of toxin-producing fungi and their importance in animal feeding: "From the meeting it became clear that the main problem in Europe had been caused by the introduction of the combine, which speeded the harvest but did nothing to dry the grain. Damp grain stored in silos was attacked by fungi. Once these had sporulated nothing could remove the mycotoxins. Farmers, grain chandlers and feed processors all faced high financial loss if the mould-damaged stocks were condemned".[10]

IMPOSSIBILITY OF ADEQUATE INSPECTION

The poultry industry has now reached dimensions which make any adequate inspection impossible. The EEC is trying very hard to have packing stations brought up to a specified standard of hygiene, registered and supplied with trained inspectors. The view has been expressed (see *Environmental Health,* March 1975) that these inspectors would be required to operate on the evisceration line, doing a dull and monotonous job at high speed. "It is inconceivable that large numbers of inspectors of the standard of education proposed could be recruited for this type of work." The Ministry of Agriculture has been playing for time and the regulations are not proposed for the U.K. until 1976, but, as not a single poultry meat inspector with the required qualifications has yet been trained, it is obvious that this date must be put back, and the year 1982 is now being considered. Possibly unemployment may by then have reached such a volume that trained personnel will be prepared to spend their working lives eyeing the innards of birds passing before them at the rate of 4,000 an hour. Meanwhile the incidence of food poisoning continues to rise, and in addition to the wholesale slaughter at the packing stations we have large numbers of birds killed in markets without the most rudimentary hygiene, evisceration taking place amid feathers, blood and excreta, live and dead birds, and no washing facilities for the operator. No Minister responsible for food and without other fish to fry, could tolerate this.

It is now well established that the meat from intensively reared animals has a high content of low quality fat and may be directly connected with the growing incidence of arterio-sclerosis. The results of research at the Nuffield Institute of Comparative Medicine are quite familiar to our Agriculture Ministers, who seem unperturbed. When a mountain of beef piles up, the solution proposed by the Minister of Agriculture is to sell it off cheap to Old Age Pensioners, inspite of the fact that the Medical and Agricultural Research Councils have found that low protein diets, late in life, slow down the process of ageing.

VESTED INTERESTS

Volumes are now being written about deficiency diseases, not as they appear in regions of poverty, but in the developed countries where people take in too much rather than too little food. The result is a growth industry of vitamin and other dietary supplements which may do some good, but in view of the complicated nature of the problem, some positive harm. Other problems emerge in this field: nutritionists often disagree and this is scarcely surprising in view of the literal truth that one man's meat is another's poison. Hard and fast rules are difficult to establish. Where does one look for basic truths? There are some organisations whose titles invite confidence, but on closer examination reveal vested interests of one kind or another. The Office of Health Economics sounds innocent enough, but is described as the "trumpet organisation" of the Pharmaceutical Industry.* Its publication of a document designed to put at rest all unease concerning the use of

* *Advertisement for "Insectflash".*

* *The Guardian, 25.6.69.*

antibiotics for livestock, just when the Swann Report was expected to put a damper on such use, certainly left a nasty taste.[13] The British Nutrition Foundation claims independence, and publishes some interesting papers, but is financed by a long list of food manufacturers and processors, intensive livestock enterprises and pharmaceutical companies. It does not seem to have put out anything detrimental to any of these, and its director-general makes statements like:

> "On the one hand there is the practice of 'factory-farming': on the other the possibility of ill-fed families. In an enforced choice between these two I for one would plump most positively for 'factory-farming' ".[14]

The steadily growing numbers of animals used in toxicity experiments indicate that there is disquiet about what goes on in our food production. The value of these experiments is, however, questionable, partly because different species have a varied reaction to foods (a reaction which can also vary within a species) and partly because laboratory conditions are not (yet) comparable with those in which the average human-being passes his existence. Surely in this subject above all others the proper study of mankind is man? The most valuable research seems to have been carried out by individuals and organisations who have taken a positive approach and observed human-beings living in a state of general good health without the assistance of sophisticated medicine. Thus, for example, racial studies have shown exceptional vigour and longevity in the Hunzas, and certain Ecuadorians and Georgians. A world-wide relationship has also been established between the frequency of diabetes and consumption of refined carbohydrates and sugar; the importance of roughage in avoiding diverticulitis and other diseases of the colon is well established, while the almost non-existence of cancer of the colon is coincident with the diet containing little fat or animal protein.[16]

For years animal fat has been implicated in serious health problems, yet there appears to be no record of our Ministers responsible for Food or Health having done or said anything to warn people either of the danger of too much animal fat in the diet, or of the greatly increased quantity of low-quality fat in the intensively bred animal and milk from the modern cow.[17] On the contrary, we are urged to "Drinka Pinta"; butter is distributed to the elderly and farmers are told to produce beef "at a price the consumer can afford" (an ambiguous statement by the present Agriculture Minister, but presumably intended to encourage intensive production by stimulated growth).

It is ironical that the health of our "affluent" society is appreciably inferior to that of wartime Britain. In fact, nutritionists claim we were never so healthy as during the period of rationing (1940-1948). One of the most significant contributions to the nation's health seems to have been an exercise by Jack Drummond at the Ministry of Food, who drew up a nutrition balance sheet, setting out the actual food requirements of the population, including vulnerable groups; the total nutritional content of the food supply, and in what respects it was lacking.[18] Hence the special supplements for such groups as expectant mothers, with not only a fall in perinatal mortality to the lowest figure ever recorded (and this at a time of great social stress) but apparently lasting benefit to children from the enlightened wartime food policy.[19]

THE MEDICAL PROFESSION

The medical profession is not blind as a whole to the hazards of our modern eating habits and the contamination of our food. Dr A.E. M. McLean of University College Medical School told an international symposium on the Health Challenge of Foods in 1972 that the food industry may now be in the position of the tobacco industry of 50 years ago – selling the customer a product of unknown hazard; that both cancer and coronary heart disease are strongly linked to long-term dietary patterns, and suggested a better-informed approach to food could result in longer life and freedom from chronic disease. Observation has shown that for cancer of the stomach, liver, oesophagus and

other organs there is a wide variation in incidence between different countries and between social groups within countries.

While the number of doctors who speak out is small, those who do don't pull their punches. At the Oxford Farming Conference in 1971 Dr G. R. Dickson, who has taken up farming, pointed out that the average farmer finds himself under commercial pressure to use new products without being able to judge their long-term effects on the countryside in general or on his own profitability, being constantly urged to apply more vitamins, vaccines, anthelmintics, fungicides, pesticides, trace elements etc., when he might be better engaged in raising the natural resistance to disease in livestock.[21]

Dr Robert Blomfield, M.B., Ch.B., has more than once drawn attention to the unhealthy state of Western medicine, pointing out that we are what we eat and breathe, and need an emphasis on naturally grown unprocessed foods, uncooked or properly cooked, deploring the "denatured health damaging foods which are promoted by the food industry". Most people, he says, "buy what the advertisers tell them to, as they, and the doctors, who should be advising them, know no better".

He is fully conscious of the inferior food served in hospitals: "I would venture to suggest that one good hospital chef could be worth any number of hospital consultants" and suggests "if a fraction of the money spent on research into the treatment of disease by drugs was used to investigate the relationship of diet to disease the health of the people in this country could be dramatically improved across the board. But much of this research is financed by drug companies who have a vested interest, not surprisingly, in drug treatment. And if one looks at it closely, so do most doctors".[22]

Dr Michael Crawford, tells us, in connection with the high-saturated fat, low quality meat produced by intensive systems, that:

> "An attempt at prevention based on 'supplying' a proper balance of structural fat, and reversal based on 'rebuilding' could theoretically be surprisingly simple. But from a practical viewpoint it would be difficult in so far as it touches on almost every aspect of food technology".[23]

Other doctors who have expressed deep concern at the effects of modern food production on the nation's health are Dr Hugh Sinclair and Dr Denis P. Birkitt, both of whom suggest factory-farming as a cause of serious disease in humans.[24] Dr Richard Cremlyn, B.Sc., F.R.I.C.S., suggests that the prevalance of certain diseases like cancer may be due to some food additive which we consume regularly and which gradually initiates a malignant reaction chain ultimately resulting in disease: "The growth of factory-farming, quite apart from the moral aspect of the exploitation of living animals to provide us with cheap food, suggests that we could in the long run pay very dearly for such products".[25]

If a fraction of the money spent on research into the treatment of disease by drugs was used to investigate the relationship of diet to disease, the health of the people of this country could be dramatically improved.

Conclusions

All in all, it might seem that we do most urgently need a Minister of Nutrition, a Minister of Food and Health, or a Minister of Health and Land Use, as suggested by Lindsay Robb. But to what degree could we be sure that he could speak and act independently? There are now such immense vested interests in our agricultural and food industries that, short of a war which would throw everything into the melting pot, one wonders what could be achieved within our present institutions. Clifford Selly, farmer, foresees a time when husbandmen are reduced to the status of share croppers, dependent on the food processors not only to buy their crops but also to supply the capital to keep them going. Already the animal feed compounders supply the standard animal to eat their standard meal. White meat is produced increasingly by processors. Large processing firms, he points out, are part of the industrial complex and are motivated by the pursuit of industrial rather than agricultural needs: "What in fact is at risk is the whole biological balance which has been the basis of good British husbandry for generations". Selly considers the record of the mammoth technological concerns interested in the convenience food market "not very reassuring, as farmers who have had dealings with them know only too well. They are so large and so powerful that inevitably they come to dominate their suppliers, even when these are banded together in co-operative groups". He stresses the danger that they will not only dominate the individual farmer but also the countryside. "The requirements of their factories will determine the type of landscape which all of us will have to inhabit". Farmers are told "that the all important mass market is now dominated by mindless automatons hell-bent on buying something cheap, tasteless, processed and packaged. To all the clever people manipulating this mass-market, food is not what most of us understand by food; it is a technological product like toothpaste or haircream, scientifically designed to fulfil the desires which the posters have unearthed from our mass subconscious".[26]

Preserving food is a time-honoured practice, but the incredible number of chemicals which go into our modern "convenience" foods are for the most part unnecessary, vitiate the palate and may hold considerable dangers.

> "The main objective of the food technologist", we are told by two nutritionists, "is to improve food quality, to develop preservation methods and invent new foods and processes so that an expanding variety of products may be marketed in an ever-increasing geographic area at a reasonable price.

To him food quality is primarily colour, flavour, texture, appearance and stability. Little attention is paid to the nutritive value of

products – as affected by a new process, ingredient, additive etc. The food industry appears to consider nutritionists *'persona non grata'* and seldom includes them in research and development teams. . . The marriage of food technology and nutrition is in our opinion important to the welfare of mankind".[27]

It may be questioned whether a Minister responsible for nutrition could make a successful stand against some of the mighty interests involved. He might well meet opposition even in his own Cabinet if he suggested a return to unadulterated food, cutting down the food technology industry and all the ancillary developments connected with factory-farming – incidentally throwing a large proportion of the population out of work. He would need strong backing from a dedicated Minister of Health, and re-deployment of labour to provide the skill and care necessary for good farming. Given the right leadership, the signs are that there might be considerable public response, but the leadership has to be created by public pressure in the first place. Members of Parliament are human like the rest of us, just as subject to coronaries and cancer, and cannot be wholly unaffected by the dangers which undoubtedly exist in our present methods of food production. Overworked doctors might also be persuaded that it is in their own interests to have the basic health of the nation put on a sounder footing. There is much that the man in the street can do just by passing on the facts – to his M.P., G.P., colleagues, friends, and especially the Press, and by opting out of such obviously dubious foods as white bread, white sugar, battery eggs, broiler poultry, intensive veal and pig-meat. The recent rise in the price of vegetables has persuaded many people to grow their own, by this means re-discovering the taste of food: we may be on the verge of a food revolution.

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ENERGY AND ECONOMIC

by Nicholas Georgescu–Roegen

This article is an attempt to examine modern Economics in the light of physical realities, which modern economists working in a veritable vacuum, have tended to ignore.

Since it is quite long, too carefully argued and too important to edit, we are publishing it in two separate instalments.

So you can now all go home and sleep peacefully in your beds tonight secure in the knowledge that in the sober and considered opinion of the latest occupant of the second oldest Chair in Political Economy in this country, although life on this Earth is very far from perfect there is no reason to think that continued economic growth will make it any worse.

Wilfred Beckerman

I. Introduction

There is an appreciable grain of truth in one of Percy Bridgman's remarks that the economic profession is the most opportunistic of all. Indeed, economists' attention has continually shifted from one problem to another, the problems often being not even closely related. Search all economic periodicals of the English-speaking world before 1950, for example, and you will hardly find any mention of "economic development." It is curious, therefore, that economists have over the last hundred years remained stubbornly attached to one particular idea, the mechanistic epistemology which dominated the orientation of the founders of the Neoclassical School. By their own proud admission, the greatest ambition of these pioneers was to build an economic science after the model of mechanics – in the words of W. Stanely Jevons – as *"the mechanics of utility and self-interest"* [1]. Like almost every scholar and philosopher of the first half of the nineteenth century, they were fascinated by the spectacular successes of the science of mechanics in astronomy and accepted Laplace's famous apotheosis of mechanics [2] as the evangel of ultimate scientific knowledge. They thus had some attenuating circumstances, which cannot, however, be invoked by those who came long after the mechanistic dogma had been banished even from physics [3, 4].

The latter-day economists, without a single second thought, have apparently been happy to develop their discipline on the mechanistic tracks laid out by their forefathers, fiercely fighting any suggestion that economics may be conceived otherwise than as a sister science of mechanics. The appeal of the position is obvious. At the back of the mind of almost every standard economist there is the spectacular feat of Urbain Leverrier and John Couch Adams, who discovered the planet Neptune, not by searching the real firmament, but "at the tip of a pencil on a piece of paper." What a splendid dream to be able to predict by some paper-and-pencil operations alone where a particular stock will be on the firmament of the Stock Exchange Market tomorrow or, even better, one year from now!

The consequence of this indiscriminate attachment to the mechanistic dogma, whether in an explicit or a tacit manner, is the viewing of the economic process as a mechanical analogue consisting – as all mechanical analogues do – of a principle of conservation (transformation) and a maximization rule. The economic science itself is thus reduced to a *timeless* kinematics. This approach has led to a mushrooming of paper-and-pencil exercises and increasingly complicated econometric models which often serve only to conceal from view the most fundamental economic issues. Everything now turns out to be just a pendulum movement. One business "cycle" follows another. The pillar of equilibrium theory is that, if events alter the demand and supply propensities, the economic world always returns to its previous conditions as soon as these events fade out. An inflation, a catastrophic drought, or a stock-exchange crash leaves absolutely no mark on the economy. Complete reversibility is the general rule, just as in mechanics.*

Nothing illustrates better the basic epistemology of standard economics than the usual graph by which almost every introductory manual portrays the economic process as a self-sustaining, circular flow between "production" and "consumption". But even money does not circulate back and forth within the economic process; for

**Some economists have insisted that, on the contrary, irreversibility characterizes the economic world, but the point, though never denied, was simply shelved away. It is in vain that some now try to claim that standard equilibrium analysis has always considered negative feedbacks. The only feedbacks in standard theory are those responsible for maintaining equilibrium, not for evolutionary changes.*

MYTHS - PART 1

both bullion and paper money ultimately become worn out and their stocks must be replenished from external sources [5]. The crucial point is that the economic process is not an isolated, self-sustaining process. This process cannot go on without a continuous exchange which alters the environment in a cumulative way and without being, in its turn, influenced by these alterations. Classical economists, Malthus in particular, insisted on the economic relevance of this fact. Yet, both standard and Marxist economists chose to ignore the problem of natural resources completely, so completely that a distinguished and versatile economist recently confessed that he had just decided that he "ought to find out what economic theory has to say" about that problem [6].

One fundamental idea dominated the orientation of both schools. A.C. Pigou stated it most explicitly: "In a stationary state factors of production are stocks, unchanging in amount, out of which emerges a continuous flow, also unchanging in amount, of real income" [7]. The same idea – that a constant flow can arise from an unchanging structure – is at the basis of Marx's diagram of simple reproduction [8. Vol 2. Ch. xx and xxi]. In the diagram of expanded reproduction Marx actually anticipated the modern models – such as that with which W.W. Leontief swept the profession off its feet – which ignore the problem of the primary source of the flow even in the case of a growing economy. The only difference is that Marx preached overtly that nature offers us everything gratis, while standard economists merely went along with this tenet tacitly. Both schools of thought shared, therefore, the Pigouvian notion of a stationary state in which a material flow emerges from an invariable source. In this idea there lies the germ of an economic myth which, as we shall see (Section VIII), is now preached by many concerned ecologists and some awakened economists. The myth is that a stationary world, a zero-growth population, will put an end to the ecological conflict of mankind. Mankind will no longer have to worry about the scarcity of resources or about pollution – another miracle-program to bring the New Jerusalem into the earthly life of man.

Myths have always occupied a prominent role in the life of man. To be sure, to act in accord with a myth is the distinctive characteristic of man among all living beings. Many myths betray man's greatest folly, his inner compulsion to believe that he is above everything else in the actual universe and that his powers know no limits. In Genesis man proclaimed that he was made in the image of God himself. At one time, he held that the entire universe revolves around his petty abode – at another, that only the sun does so. Once, man believed that he could move things without consuming any energy, which is the myth of perpetual motion of the first kind – certainly, an essentially economic myth. The myth of perpetual motion of the second kind, which is that we may use the same energy over and over again, still lingers on in various veiled forms.

Another economic myth – that man will forever succeed in finding new sources of energy and new ways of harnessing them to his benefit – is now propounded by some scientists, but especially by economists of both standard and Marxist persuasions (Section VI). Come what may, "we will [always] think up something" [9]. The idea is that, if the individual man is mortal, at least the human species is immortal. Apparently, it is below man's dignity to accept the verdict of a biological authority such as J.B.S. Haldane that the most certain fate of mankind is the same as that of any other species, namely, extinction. Only, we do not know when and why it will come. It may be sooner than the optimists believe or much later than the pessimists fear. Consequences of the accumulation of environmental deterioration may bring it about; but some persistent virus or a freak infertility gene may also cause it.

The fact is that we know little about why any species bowed out in the past, not even why some seem to become extinct before our own eyes. If we can predict approximately how long a given dog will live and also what will most probably end its life, it is only because we have had repeated occasions to observe a dog's life from birth to death. The predicament of the evolutionary biologist is that he has never observed another human species being born, aging, and dying [10, 11]. However, a species reaches the end of its existence by a process analogous to the aging of any individual organism. And even though aging is still surrounded by many mysteries [11], we know that the causes which bring about the end of a species work slowly, but *persistently and cumulatively*, from the first moment of its birth. The point is that everyone of us ages with each minute, nay, with each blink, even though we are unable to realize the difference.

It is utterly inept to argue – as some economists implicitly do – that since mankind has not met with any ecological difficulty since

ENERGY AND ECONOMIC MYTHS - PART 1

the age of Pericles, it will never meet with one (Section VI). If we keep our eyes open, however, we will detect, as time goes by, some sufficiently apparent symptoms which may help us to arrive at some general idea of the probable causes of aging and, possibly, of death. True, man's needs and the kinds of resources required for their satisfaction are far more complex than those of any other species. In exchange, our knowledge of these factors and their interrelations is, naturally, more extensive. The upshot is that even a simple analysis of the energy aspects of man's existence may help us to reach at least a general picture of the ecological problems and arrive at a few, but relevant, conclusions. This, *and nothing else,* is what I have endeavored to do in this paper.

II. Mechanics Versus Thermo-Dynamics.

No analysis of a material process, whether in the natural sciences or economics, can be sound without a clear and comprehensive analytical picture of such a process. The picture must first of all include the boundary – an abstract and void element which separates the process from its "environment" – as well as the duration of the process. What the process needs and what it does are then described analytically by the complete time schedule of all inputs and outputs, i.e., the precise moments at which each element involved crosses the boundary from outside or from inside. But where we draw the abstract boundary, what duration we consider, and what qualitative spectrum we use for classifying the elements of the process depend on the particular purpose of the student, and by and large on the science in point.

Mechanics distinguishes only mass, speed, and position, on which it bases the concept of kinetic and potential energy. The result is that mechanics reduces any process to locomotion and a change in the distribution of energy. The constancy of total mechanical energy (kinetic plus potential) and the constancy of mass are the earliest principles of conservation to be recognized by science. A few careful economists, such as Marshall [12], did observe that man can create neither matter nor energy. But in doing so, they apparently had in mind only the *mechanical* principles of conservation, for they immeddiately added that man can nevertheless produce utilities by moving and rearranging matter. This viewpoint ignores a most important issue: How can man do the moving? For anyone who remains at the level of mechanical phenomena, every bit of matter and every bit of mechanical energy which enter a process must come out in exactly the same *quantity* and *quality*. Locomotion cannot alter either.

To equate the economic process with a mechanical analogue implies, therefore, the myth that the economic process is a circular merry-go-round which cannot possibly affect the environment of matter and energy in any way. The obvious conclusion is that there is no need for bringing the environment into the analytical picture of that process* . The old tenet of Sir William Petty, that keen student of human affairs who insisted that labor is the father and nature the mother of wealth, has long since been relegated to the status of a museum piece [10, 5]. Even the accumulation of glaring proofs of the preponderant role played by natural resources in mankind's history failed to impress standard economists. One may think of the Great Migration of the first millenium which was the ultimate response to the exhaustion of the soil of Central Asia following a long period of persistent grazing. Remarkable civilizations – Maya is one example – crumbled away from history because their people were unable to migrate or to counteract by adequate technical progress the deterioration of their environment. Above all, there is the indisputable fact that all struggles between the Great Powers have not turned idly around ideologies or national prestige but around the control of natural resources. They still do.

Because mechanics recognizes no qualitative change but only change of place, any mechanical process may be reversed, just as a pendulum, for instance, can. No laws of mechanics would have been violated if the earth had been set in motion in the opposite direction. There is absolutely no way for a spectator to discover whether a movie of a purely mechanical pendulum is projected in the direction in which it was taken or in the reverse. But actual phenomena in all their aspects do not follow the story of the famous Mother Goose rhyme in which the brave Duke of York kept marching his troops up the hill and down the hill without giving battle. Actual phenomena move in a definite direction and involve qualitative change. This is the lesson of thermodynamics, a peculiar branch of physics, so peculiar that purists prefer not to consider it a part of physics because of its anthropomorhpic texture. Even though it is hard to see how the basic texture of any science could be otherwise than anthropomorphic, the case of thermodynamics is unique.

Thermodynamics grew out of a memoir by a French engineer, Nicolas Sadi Carnot, on the efficiency of heat engines (1824). Among the first facts it brought to light is that man can use only a particular form of energy. Energy thus came to be divided into *available* or *free* energy, which can be transformed into work, and *unavailable* or *bound* energy, which cannot be so transformed. Clearly, the division of energy according to this criterion is an anthropomorphic distinction like no other

If "land" appears as a variable in some standard production functions, it stands only for Ricardian land, i.e., for mere space. The lack of concern for the true nature of the economic process is also responsible for the inadequacy of the standard production from other, equally crucial, viewpoints.

in science.

The distinction is closely related to another concept specific to thermodynamics, namely, to entropy. This concept is so involved that one specialist judged that "it is not easily understood even by physicists" [13]. But for our immediate purpose we may be satisfied with the simple definition of entropy as an *index* of the amount of unavailable energy in a given thermodynamic system at a given moment of its evolution.

Energy, regardless of quality,* is subject to a strict conservation law, the First Law of Thermodynamics, which is formally identical to the conservation of mechanical energy mentioned earlier. And since work is one of the multiple forms of energy, this law exposes the myth of perpetual motion of the first kind. It does not, however, take account of the distinction between available and unavailable energy; *by itself the law does not preclude the possibility that an amount of work should be transformed into heat and this heat reconverted into the initial amount of work.* The First Law of Thermodynamics thus allows any process to take place both forward and backward, so that everything is again just as it was at first, with no trace left by the happening. With only that law we are still in mechanics, not in the domain of actual phenomena, which certainly includes the economic process.

The irreducible opposition between mechanics and thermodynamics stems from the Second Law, the Entropy Law. The oldest of its multiple formulations is also the most transparent for the nonspecialist: "Heat flows by itself only from the hotter to the colder body, never in reverse." A more involved but equivalent formulation is that the entropy of a *closed* system continuously (and irrevocably) increases toward a maximum; i.e. the available energy is continuously transformed into unavailable energy until it disappears completely.**

In broad lines, the story is relatively simple: *All kinds of energy are gradually transformed into heat and heat becomes so dissipated in the end that man can no longer use it.* Indeed, a point that goes back to Carnot is that no steam engine can provide work if the same temperature, however high, prevails in the boiler and the cooler.*** To be available, energy must be distributed unevenly; energy that is completely dissipated is no longer available. The classical illustration is the immense heat dissipated into the water of the seas, which no ship can use. Although ships sail on top of it, they need available energy, the kinetic energy concentrated in the wind or the chemical and nuclear energy concentrated in some fuel. We may see why entropy came to be regarded also as an index of disorder (of dissipation) not only of energy but also of *matter* and why the Entropy Law in its present form states that *matter, too, is subject to an irrevocable dissipation.* Accordingly, the ultimate fate of the universe is not the Heat Death (as it was believed at first) but a much grimmer state – Chaos. No doubt, the thought is intellectually unsatisfactory. But what interests us is that, according to all the evidence, our immediate environment, the solar system, tends toward a thermodynamic death, at least as far as life-bearing structures are concerned.

III. The Entropy Law and Economics

Perhaps no other law occupies a position in science as singular as that of the Entropy Law. It is the only natural law which recognizes that even the material universe is subject to an irreversible qualitative change, to an evolutionary process. This fact led some natural scientists and philosophers to suspect an affinity between that law and life phenomena. By now, few would deny that the *economy* of any life process is governed, not by the laws of mechanics, but by the Entropy Law [11, xiii]. The point, as we shall now see, is most transparent in the case of the economic process.

Economists have occasionally maintained that, since some scieentists trespass into economics without knowing much about the subject, they, too, are justified in talking about science, notwithstanding their ignorance in that domain [9]. The thought reflects an error, which unfortunately is general with economists. But whatever the economic expertise of other scientists, economists could not fare continuously well in their own field without some solid understanding of the Entropy Law and its consequences. As I argued some years ago, thermodynamics is at bottom a physics of economic value – as Carnot unwittingly set it going – and the Entropy Law is the most economic in nature of all natural laws [10, 11].

The economic process, like any other life process, is irreversible (and irrevocably so); hence, it cannot be explained in mechanical terms alone. It is thermodynamics, through the Entropy Law, that recognizes the qualitative distinction which economists should have made from the outset between the inputs of valuable resources (low entropy) and the final outputs of valueless waste (high entropy). The paradox suggested by this thought, namely, that all the economic process does is to transform valuable matter and energy into waste, is easily and instructively resolved. It compels us to recognize that the real output of the economic process (or of any life process, for that matter) is not the *material flow* of waste, but the still mysterious *immaterial flux* of

Let us also note that even energy does not lend itself to a simple, formal definition. The familiar one, that energy is the capacity of a system to perform work, clashes with the definition of unavailable energy. We must then explain that all energy can in principle be transformed into work provided that the corresponding system is brought into contact with another which is at the absolute zero of temperature. This explanation has only the value of a pure extrapolation because, according to the Third Law of Thermodynamics, this temperature can never be reached.

**A system is closed if it exchanges no matter and no energy with its "environment". Clearly, in such a system the amount of matter-energy is constant. However, the constancy of this amount alone does not warrant the increase of entropy. Entropy may even decrease if there is exchange.*

***There is no truth, therefore, in Holdren's idea that temperature measures "the usefulness" of heat. The most we can say is that the difference of temperature is a rough index of the usefulness of the hotter heat.*

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the enjoyment of life.* Without recognizing this fact we cannot be in the domain of life phenomena.

The present laws of physics and chemistry do not explain life completely. But the thought that life may violate some natural law has no place in science. Nevertheless, as has long been observed – and more recently in an admirable exposition by Erwin Schrödinger [14] – life seems to evade the entropic degradation to which inert matter is subject. The truth is that any living organism simply strives at all times to compensate for its own continuous degradation by sucking low entropy (negentropy) and expelling high entropy. Clearly, this phenomenon is not precluded by the Entropy Law, which requires only that the entropy of the entire system (the environment *and* the organism) should increase. Everything is in order as long as the entropy of the environment increases by more than the compensated entropy of the organism.

Equally important is the fact that the Entropy Law is the only natural law that does not predict quantitatively. It does not specify how great the increase should be at a future moment or what particular entropic pattern will result. Because of this fact, there is an entropic indeterminateness in the real world which allows not only for life to acquire an endless spectrum of forms but also for most actions of a living organism to enjoy a certain amount of freedom [11]. Without this freedom, we would not be able to choose between eating beans or meat, between eating now or later. Nor could we aspire to implement economic plans (at any level) of our own choosing.

It is also because of the entropic indeterminateness that life does matter in the entropic process. The point is no mystical vitalism, but a matter of brute facts. Some organisms slow down the entropic degradation. Green plants store *part* of the solar radiation which in their absence would immediately go into dissipated heat, into high entropy. That is why we can burn now the solar energy saved from degradation millions of years ago in the form of coal or a few years ago in the form of a tree. All other organisms, on the contrary, speed up the march of entropy. Man occupies the highest position on this scale, and this is all that environmental issues are about.

Most important for the student of economics is the point that the Entropy Law is the taproot of economic scarcity. Were it not for this law, we could use the energy of a piece of coal over and over again, by transforming it into heat, the heat into work, and the work back into heat, Also, engines, homes, and even living organisms (if they could exist at all) would never wear out. There would be no economic difference between material goods and Ricardian land. In such an imaginary, purely mechanical world, there would be no true scarcity of energy and materials. A population as large as the space of our globe would allow could live indeed forever. An increase in the real income per capita could be supported in part by a greater velocity of use (just as in the case of money circulation) and in part by additional mining. But there would be no reason for any real struggle, whether intra-species or inter-species, to arise.

Economists have been insisting that "there is no free lunch," by which they mean that the price of anything must be equal to the cost; otherwise, one would get something for nothing. To believe that this equality also prevails in terms of entropy constitutes one of the most dangerous economic myths. *In the context of entropy, every action, of man or of an organism, nay, any process in nature, must result in a deficit for the entire system.* Not only does the entropy of the environment increase by an additional amount for every gallon of gasoline in your tank, but also a substantial part of the free energy contained in that gasoline, instead of driving your car, will turn directly into an additional increase of entropy. As long as there are abundant easily accessible resources around, we might not really care how large this additional loss is. Also, when we produce a copper sheet from some copper ore we decrease the entropy (the disorder) of the ore, but only at the cost of a much greater increase of the entropy in the rest of the universe. If there were not this entropic deficit, we would be able to convert work into heat, and, by reversing the process, to recuperate the entire initial amount of work – as in the imaginary world of the preceding paragraph. In such a world, standard economics would reign supreme precisely because the Entropy Law would not work.

IV. Accessible Energy and Accessible Matter.

As we have seen, the distinction between available and unavailable energy (generalized by that between low and high entropy) was introduced in order that thermodynamics may take into account the fact that only one particular state of energy can be used by man. But the distinction does not mean that man can *actually* use any available energy regardless of the place and form in which it is found. If available energy is to have any value for mankind, it must also be *accessible.* Solar energy and its by-products are accessible to us with practically no effort, no consumption of additional available energy. In all other cases, we have to spend some work and materials in order to tap a store of available energy. The point is that even though we may land on Mars and find there some gas deposits, that available energy will not be accessible to us if it will take more than the equivalent energy of a cubic foot of gas *accessible on earth* to bring a cubic foot of gas from that planet. There certainly are oil shales from which we could extract one ton of oil only by using more than one ton of oil. The oil in such a shale would still represent available, but not accessible, energy. We have

**It seems idle therefore to ask – as Boulding does – whether well-being is a flow or a stock.*

been reminded ad nauseam that the real reserves of fossil fuel are certainly greater than those known or estimated [e.g. 15]. But it is equally certain that a substantial part of the real reserves does not constitute accessible energy.

The distinction regards efficiency in terms of energy, not in terms of economics. Economic efficiency implies energetic efficiency, but the converse is not true. The use of gas, for example, is energetically more efficient than the use of electricity, but electricity happens to be cheaper in many instances [16]. Also, even though we can make gas from coal, it is cheaper to extract gas from natural deposits. Should the natural resources of gas become exhausted before those of coal, we will certainly resort to the method that is now economically inefficient. The same idea should be borne in mind when discussing the future of direct uses of solar radiation.

Economists, however, insist that "resources are properly measured in economic, not physical terms" [17, 18]. The advice reflects one of the most enduring myths of the profession (shared also by others). It is the myth that the price mechanism can offset any shortages, whether of land, energy or materials. This myth will be duly examined later on, but here we need only emphasize the point that from the point of view of the longrun it is only efficiency in terms of energy that counts in establishing accessibility. To be sure, actual efficiency depends at any one time on the state of the arts. But, as we know from Carnot, in each particular situation *there is a theoretical limit independent of the state of the arts, which can never be attained in actuality*. In effect, we generally remain far below it.

Accessibility, as here defined, bears on the fact that although mankind's spaceship floats within a fantastic store of available energy, only an infinitesimal part of this store is potentially accessible to man. For even if we were to travel in space with the greatest speed, that of light, we would still be confined to a speck of cosmos. A journey just to scout the nearest sun outside the solar system for possible, yet uncertain, earth-like satellites would take nine years! If we have learned anything from the landing on the moon, it is that there is no promise of resources in interplanetary, let alone intersidereal, travel.

Still narrower limits to the accessible energy are set by our own biological nature, which is such that we cannot survive at too high or too low a temperature or when exposed to some radiations. It is for this reason that the mining of nuclear fuel and its use on a large scale has raised issues which now divide laymen as well as authorities on the subject (Section IX). There are also limits set by some purely physical obstacles. The sun cannot possibly be mined even by a robot. From the sun's immense radiating energy, only the small amount which reaches the earth counts in the main 'Section IX). Nor can we harness the immense energy of the terrestrial thunders. Unique physical obstacles also stand hopelessly in the way of the peaceful use of thermonuclear energy. The fusion of deuterium requires the fantastic temperatrue of 0.2 billion °F, one order of magnitude hotter than the sun's interior. The difficulty concerns the material container for that reaction. As has been explained in layman's terms, the solution now sought is similar to holding water inside a mesh of rubber bands. In this connection we may recall that the chemical energy of dynamite and gunpowder, although in use for a long time, cannot be controlled so as to drive a turbine or a motor. Perhaps the use of thermonuclear energy will also remian confined to a "bomb". Be this as it may, with or without thermonuclear energy, the amount of accessible energetic low entropy is finite (Section IV).

Similar considerations lead to the conclusion that the amount of accessible material low entropy is finite, too. But although in both cases only the amount of low entropy matters, it is important that the two accounts be kept separate in any discussion of the environmental problem. As we all know, available energy and ordered material structures fulfil two distinct roles in mankind's life. However, this anthropomorphic distinction would not be compelling by itself.

There is, first, the physical fact that, despite the Einstein equivalence of mass and energy, there is no reason to believe that we can convert energy into matter except at the atomic scale in a laboratory and only for some special elements.* We cannot produce a copper sheet, for example, from energy alone. All the copper in that sheet must exist as copper (in pure form or in some chemical compound) beforehand. Therefore, the statement that "energy is convertible into most of the other requirements of life" [19] is, in this unqualified form, apt to mislead. Second, no material macrostructure (whether a nail or a jet) whose entropy is lower than that of its surroundings may last forever in its original form. Even the singular organizations characterized by the tendency to evade the entropic decay – the life-bearing structures – cannot so last. The artifacts which now are an essential part of our mode of life have therefore to be renewed continuously from some sources. The final point is that the earth is a thermodynamic system open only with respect to energy. The amount of meteorite matter, though not negligible, comes already dissipated.

The result is that we can count only on the mineral resources, which, however, are both irreplaceable and exhaustible. Many of a particular kind have been exhausted in one country after another [20]. At present, important minerals – lead, tin, zinc, mercury, precious metals – are scarce over the entire world [21, 20]. The wide-spread notion that the oceans constitute an almost inexhaustible source of minerals and may even become a link in a perpetual, natural recycling system [18, 22] is denounced as mere hyperbole by geological authorities [21].**

The point is that even the formation of an atom of carbon from three atoms of helium, for example, requires such a sharp timing that its probability is astronomically small, and hence the event may occur on a large scale only within astronomically huge masses.

**The widespread notion that the oceans may be turned into an immense source of food is also a great delusion.*

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The only way we can substitute energy for material low entropy is through physico-chemical manipulations. By using larger and larger amounts of available energy we can sift copper out from poorer and poorer ores, located deeper and deeper in the earth. But the energy cost of mining low-content ores increases very fast [20]. We can also recycle "scrap." There are, however, some elements which, because of their nature and the mode in which they participate in the natural and man-conducted processes, are highly dissipative. Recycling, in this case, can hardly help. The situation is particularly distressing for those elements which, in addition, are found in very small supply in the environment. Phosphorus, a highly critical element in biological processes, seems to belong to this category. So does helium, another element with a strictly specific role [21, 23].

An important point – apparently ignored by economists [24, 22] – is that recycling cannot be complete. Even though we can pick up all the pearls from the floor and reconstitute a broken necklace, no actual process can possibly reassemble all the molecules of a coin after it has been worn out.

This impossibility is not a straightforward consequence of the Entropy Law, as Solow believes [6]. Nor is it quite exact to say, with Boulding [25], that "there is, fortunately, no law of increasing material entropy." The Entropy Law does not distinguish between matter and energy. This law does not exclude (at least not in principle) a complete unshuffling of a *partial* material structure, provided that there is enough free energy to do the job. And if we have enough energy, we could even separate the cold molecules of a glass of water and assemble them into ice cubes. If, in practice, however, such operations are impossible, it is only because they would require a practically infinite time.

V. Disposable Waste

Since Malthus did not see that waste also raises some economic problems, it was normal for the schools of economic thought which ignored even the input of natural resources to pay no attention to the output of waste. As a result, waste, just like natural resources, is not represented in any manner in the standard production function. The only mention of pollution was the occasional textbook example of the laundry enterprise which suffers a loss because of a neighboring smokestack. Economists must therefore have felt some surprise when pollution started to strike everybody in the face. Yet, there was nothing to be surprised about. Given the entropic nature of the economic process, waste is an *output* just as unavoidable as the input of natural resources [26]. "Bigger and better" motorcycles, automobiles, jet planes, refrigerators, etc., necessarily cause not only "bigger and better" depletion of natural resources but also "bigger and better" pollution [5]. But by now, economists can no longer ignore the existence of pollution. They even have suddenly discovered that they "actually have something important to say to the world", namely, that if prices are right there is no pollution [27, 28, 24, 29] – which is another facet of the economists' myth about prices (Sections IV and XI).

Waste is a physical phenomenon which is, generally, harmful to one or another form of life, and, directly or indirectly, harmful to human life. It constantly deteriorates the environment in many ways: chemically, as in mercury or acid pollution; nuclearly, as by radioactive garbage; physically, as in strip mining or in the accumulation of carbon dioxide in the atmosphere. There are a few instances in which a substantial part of some waste element – carbon dioxide is the salient example – is recycled by some "natural" processes of the environment. Most of the obnoxious waste – garbage, cadavers, and excrement – is also gradually reduced by natural processes. These wastes only require some space in which to remain isolated until their reduction is completed. There are troublesome hygienic problems involved, but the important point is that such wastes do not cause permanent, irreducible harm to our environment.

Other wastes are *disposable* only in the sense that they may be converted into less noxious ones by certain actions on our part, as when part of carbon monoxide is transformed into carbon dioxide and heat through improved combustion. A great part of sulphur dioxide pollution, another example, may be avoided through some special installations. Still other wastes cannot be so reduced. A topical example is the fact that we cannot reduce the highly dangerous radioactivity of nuclear garbage [30]. This activity diminishes by itself with time, but very slowly. In the case of plutonium-239, the reduction to fifty percent takes 25,000 years! However, the harm done by radioactivity concentration to life may very well be irreparable.

Here, just as for the accumulation of any waste, from rubbish of all kinds to heat, the difficulty is created by the finitude of accessible space. Mankind is like a household which consumes the limited supply from a pantry and throws the inevitable waste into a finite trash can – the space around us. Even ordinary rubbish is a menace; in ancient times, when it could be removed only with great difficulties, some glorious cities were buried under accumulated rubbish. We have better means to remove it, but the continuous production calls for another dumping area, and another, and another . . . In the United States the annual amount of waste is almost two tons per capita and increasing [31]. We should also bear in mind that for every barrel of shale oil we are saddled with more than one ton of ashes and to obtain five ounces of uranium we must crush one cubic metre of rock. What to do even with these "neutral" residuals is a problem vividly illustrated by the consequences of strip-

mining. To send the residuals into outer space would not pay on a large and continuous scale.

The finitude of our space renders more dangerous wastes which persist for a long time and especially those which are completely irreducible. Typical of the last category is thermal pollution, the dangers of which are not fully appreciated. The *additional* heat into which all energy of terrestrial origin is ultimately transformed when used by man is apt to upset the delicate thermodynamic balance of the globe in two ways. First, the islands of heat created by power plants not only disturb (as is well known) the local fauna and flora of rivers, lakes, and even coastal seas, but they may also alter climatic patterns. One nuclear plant alone may heat up the water in the Hudson River by as much as 7°F. Then again the sorry plight of where to build the next plant, and the next, is a formidable problem. Second, the additional global heat at the site of the plant and at the place where power is used may increase the temperature of the earth to the point at which the icecaps would melt – an event of cataclysmic consequences. Since the Entropy Law allows no way to cool a continuously heated planet, thermal pollution could prove to be a more crucial obstacle than the finiteness of accessible resources [16].

We apparently believe that we just have to do things differently in order to dispose of pollution. The truth is that, like recycling, disposal of pollution is not costless in terms of energy. Moreover, as the percentage of pollution reduction increases, the cost increases even more steeply than for recycling [32]. We must therefore watch our step – as some have already warned us [33] – so as not to substitute a greater but distant pollution for a local one. In principle at least, a dead lake may certainly be revitalized by pumping oxygen into it, as Harry Johnson suggests [24]. But it is as certain that the additional operations implied by this pumping not only require enormous amounts of additional low entropy but also create additional pollution. In practice, the reclamation efforts undertaken for lands and streams degraded by strip-mining have been less than successful [31]. Linear thinking – to borrow a label used by Bormann [34] – may be "in" nowadays, but precisely as economists we ought to abide by the truth that what is true for one dead lake is not true for all dead lakes if their number increases beyond a certain limit. To suggest further that man can construct at a cost a new environment tailored to his desires is to ignore completely that cost consists in essence of low entropy, not of money, and is subject to the limitations imposed by natural laws.

Often our arguments spring from the belief in an industrial activity free of pollution. It is a myth just as lulling as the belief in everlasting durability. The sober truth is that, our efforts not withstanding, the accumulation of pollution might under certain circumstances beget the first serious ecological crisis [32]. What we experience today is only a clear premonition of a trend which may become even more conspicuous in the distant future.

VI. Myths about Mankind's Entropic Problem

Hardly anyone would nowadays openly profess a belief in the immortality of mankind. Yet many of us prefer not to exclude this possibility; to this end, we endeavor to impugn any factor that could limit mankind's life. The most natural rallying idea is that mankind's entropic dowry is virtually inexhaustible, primarily because of man's inherent power to defeat the Entropy Law in some way or another.

To begin with, there is the simple argument that, just as has happened with many natural laws, the laws on which the finiteness of accessible resources rests will be refuted in turn. The difficulty of this historical argument is that history proves with even greater force, first, that in a finite space there can be only a finite amount of low entropy and, second, that low entropy continuously and irrevocably dwindles away. The impossibility of perpetual motion (of both kinds) is as firmly anchored in history as the law of gravitation.

More sophisticated weapons have been forged by the statistical interpretation of thermodynamic phenomena – an endeavor to reestablish the supremacy of mechanics propped up this time by a *sui generis* notion of probability. According to this interpretation, the reversibility of high into low entropy is only a highly improbable, not a totally impossible event. And since the event is *possible,* we should be able by an ingenious device to cause the event to happen as often as we please, just as an adroit sharper may throw a "six" almost at will. The argument only brings to the surface the irreducible contradictions and fallacies packed into the foundations of the statistical interpretation by the worshipers of mechanics [11, ch. vi]. The hopes raised by this interpretation were so sanguine at one time that P.W. Bridgman, an authority on thermodynamics, felt it necessary to write an article just to expose the fallacy of the idea that one may fill one's pockets with money by "bootlegging entropy" [35].

Occasionally and *sotto voce* some express the hope, once fostered by a scientific authority such as John von Neumann, that man will eventually discover how to make energy a free good, "just like the unmetered air" [18]. Some envision a "catalyst" by which to decompose, for example, the sea water into oxygen and hydrogen, the combustion of which will yield as much available energy as we would want. But the analogy with the small ember which sets a whole log on fire is unavailing. The entropy of the log and the oxygen used in the combustion is lower than that of the resulting ashes and smoke, whereas the entropy of water is higher than that of the oxygen and hydrogen after decomposition. Therefore, the miraculous catalyst also implies entropy bootlegging.

With the notion, now propagated from one syndicated column to another, that the breeder reactor produces more energy than it consumes, the fallacy of entropy bootlegging seems to have reached its greatest currency even among the large circles of literati, including economists. Unfortunately, the illusion feeds on misconceived sales talk by some nuclear experts who extol the reactors which transform fertile but nonfissionable material

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into fissionable fuel as the breeders that "produce more fuel than they consume" [36]. The stark truth is that the breeder is in no way different from a plant which produces hammers with the aid of some hammers. According to the deficit principle of the Entropy Law (Section III), even in breeding chickens a greater amount of low entropy is consumed than is contained in the product.*

Apparently in defense of the standard vision of the economic process, economists have set forth themes of their own. We may mention first the argument that "the notion of an absolute limit to natural resource availability is untenable when the definition of resources changes drastically and unpredictably over time. . . . A limit may exist, but it can be neither defined nor specified in economic terms" [18]. We also read that there is no upper limit even for arable land because "arable is infinitely indefinable" [37]. The sophistry of these arguments is flagrant. No one would deny that we cannot say *exactly* how much coal, for example, is accessible. Estimates of natural resources have constantly been shown to be too low. Also, the point that metals contained in the top mile of the earth's crust may be a million times as much as the present known reserves [9, 15] does not prove the inexhaustibility of resources, but, characteristically, it ignores both the issues of accessibility and disposability. Whatever resources or arable land we may need at one time or another, they will consist of accessible low entropy and accessible land. *And since all kinds together are in finite amount, no taxonomic switch can do away with that finiteness.*

The favorite thesis of standard and Marxist economists alike, however, is that the power of technology is without limits [18, 9, 28, 24, 17, 27, 22]. We will always be able not only to find a substitute for a resource which has become scarce, but also to increase the *productivity* of any kind of energy and material. Should we run out of some resources, we will always think up something just as we have continuously done since the time of Pericles [9]. Nothing, therefore, could ever stand in the way of an increasingly happier existence of the human species. One can hardly think of a more blunt form of linear thinking. By the same logic, no healthy young human should ever become afflicted with rheumatism or any other old-age ailments; nor should he ever die. Dinosaurs, just before they disappeared from this very same planet, had behind them not less than one hundred and fifty million years of truly prosperous existence. (And they did not pollute environment with industrial waste!). But the logic to be truly savored is Solo's [38]. If entropic degradation is to bring mankind to its knees sometime in the future, it should have done so sometime after A.D. 1000. The old truth of Seigneur de La Palice has never been turned around – and in such a delightful form.**

In support of the same thesis, there also are arguments directly pertaining to its substance. First, there is the assertion that only a few kinds of resources are "so resistant to technological advance as to be incapable of eventually yielding extractive products at constant or declining cost" [18]. More recently, some have come out with a specific law which, in a way, is the contrary of Malthus' law concerning resources. The idea is that technology improves exponentially [9, 17, 27]. The superficial justification is that one technological advance induces another. This is true, only it does not work cumulatively as in population growth. And it is terribly wrong to argue, as Maddox does [39], that to insist on the existence of a limit to technology means to deny man's power to influence progress. Even if technology continues to progress, it will not necessarily exceed any limit; an increasing sequence may have an upper limit. In the case of technology this limit is set by the theoretical coefficient of efficiency (Section IV). If progress were indeed exponential, then the input i per unit of output would follow in time the law $i = i_0 (1 + r)^{-t}$ and would constantly approach zero. Production would ultimately become incorporeal and the earth a new Garden of Eden.

Finally, there is the thesis which may be called the fallacy of endless substitution: "Few components of the earth's crust, including farm land, are so specific as to defy economic replacement; . . . nature imposes particular scarcities, not an inescapable general scarcity" [18]. Bray's protest notwithstanding [28], this *is* "an economist's conjuring trick." True, there are only a few "vitamin" elements which play a totally specific role such as phosphorus plays in living organisms. Aluminium, on the other hand, has replaced iron and copper in many, although not in all uses.*** However, *substitution within a finite stock of accessible low entropy* whose irrevocable degradation is speeded up through use cannot

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How incredibly, resilient is the myth of energy breeding is evidenced by the very recent statement of Roger Revelle that "farming can be thought of as a kind of breeder reactor in which much more energy is produced than is consumed." Ignorance of the main laws governing energy is widespread indeed.

**To recall the famous old French quatrain: "Seigneur de La Palice / fell in the battle for Pavia. / A quarter of an hour before his death / he was still alive." (My translation.) See* Grand Dictionnaire *Universal du XIX-e Siecle, Vol. X, p. 179.*

***Even in this most cited case, substitution has not been as successful in every direction as we have generally believed. Recently, it has been discovered that aluminium electrical cables constitute fire hazards.*

possibly go on forever.

In Solow's hands, substitution becomes the key factor that supports technological progress even as resources become increasingly scarce. There will be, first, a substitution within the spectrum of consumer goods. With prices reacting to increasing scarcity, consumers will buy "fewer resource-intensive goods and more of other things" [27].* More recently, he extended the same idea to production, too. We may, he argues, substitute "other factors for natural resources" [6]. One must have a very erroneous view of the economic process as a whole not to see that there are no material factors other than natural resources. To maintain further that "the world can, in effect, get along without natural resources" is to ignore the difference between the actual world and the Garden of Eden.

More impressive are the statistical data invoked in support of some of the foregoing theses. The data adduced by Solow [27], show that in the United States between 1950 and 1970 the consumption of a series of mineral elements per unit of GNP decreased substantially. The exceptions were attributed to substitution but were expected to get in line sooner or later. In strict logic, the data do not prove that during the same period technology necessarily progress to a greater economy of resources. The GNP may increase more than any input of minerals even if technology remains the same, or even if it deteriorates. But we also know that during practically the same period, 1947-1967, the consumption per capita of basic materials increased in the United States. And in the world, during only one decade, 1957-1967, the consumption of steel per capita grew by 44 percent [40]. What matters in the end is not only the impact of technological progress on the consumption of resources per unit of GNP, but especially the increase in the rate of resource depletion, which is a side effect of that progress.

Still more impressive – as they have actually proved to be – are the data used by Barnett and Morse to show that, from 1870 to 1957, the ratios of labor and capital costs to net output decreased appreciably in agriculture and mining, both critical sectors as concerns depletion of resources [18]. In spite of some arithmetical incongruities,** the picture emerging from these data cannot be repudiated. Only its interpretation must be corrected.

For the environmental problem, it is essential to understand the typical forms in which technological progress may occur. A first group includes the *economy-innovations,* which achieve a *net* economy of low entropy – be it by a more complete combustion, by decreasing friction, by deriving a more intensive light from gas or electricity, by substituting materials costing less in energy for others costing more, and so on. Under this heading we should also include the discovery of how to use new kinds of accessible low entropy. A second group consists of *substitution-innovations,* which simply substitute physico-chemical energy for human energy. A good illustration is the innovation of gunpowder, which did away with the catapult. Such innovations generally enable us not only to do things better but also (and especially) to do things which could not be done before – to fly airplanes, for example. Finally, there are the *spectrum-innovations,* which bring into existence new consumer goods, such as the hat, nylon stockings, etc. Most of the innovations of this group are at the same time substitution-innovations. In fact, most innovations belong to more than one category. But the classification serves analytical purposes.

Now, economic history confirms a rather elementary fact – the fact that the great strides in technological progress have generally been touched off by a discovery of how to use a new kind of accessible energy. On the other hand, a great stride in technological progress cannot materialize unless the corresponding innovation is followed by a great mineralogical expansion. Even a substantial increase in the efficiency of the use of gasoline as fuel would pale in comparison with a manifold increase of the known, rich oil fields.

This sort of expansion is what has happened during the last one hundred years. We have struck oil and discovered new coal and gas deposits in a far greater proportion than we could use during the same period. Still more important, all mineralogical discoveries have included a substantial proportion of *easily* accessible resources. This exceptional bonanza by itself has sufficed to lower the real cost of bringing mineral resources *in situ* to the surface. Energy of mineral source thus becoming cheaper, substitution-innovations have caused the ratio of labor to net output to decline. Capital also must have evolved toward forms which cost less but use more energy to achieve the same result. What has happened during this period is a modification of the cost structure, the flow factors being increased and the fund factors decreased. By examining, therefore, only the relative variations of the fund factors during a period of exceptional mineral bonanza, we cannot prove either that the unitary total cost will always follow a declining trend or that the continuous progress of technology renders accessible resources almost inexhaustible – as Barnett and Morse claim [18].

Little doubt is thus left about the fact that the theses examined in this section are anchored in a deeply-lying belief in mankind's immortality. Some of their defenders have even urged us to have faith in the human species: such faith will

The pearl on this issue, however, is supplied by Maddox: "Just as prosperity in countries now advanced has been accompanied by an actual decrease in the consumption of bread, so it is to be expected that affluence will make societies less dependent on metals such as steel."

***The point refers to the addition of capital (measured in* money terms*) and labor (measured in* workers employed*) as well as the computation of net output (by substraction) from* physical *gross output.*

triumph over all limitations.* But neither faith nor assurance from some famous academic chair [9] could alter the fact that, according to the basic law of thermodynamics, mankind's dowry is finite. Even if one were inclined to believe in the possible refutation of these principles in the future, one still must not act on that faith now. We must take into account that evolution does not consist of a linear repetition, even though over short intervals it may fool us into the contrary belief.

A great deal of confusion about the environmental problem prevails not only among economists generally (as evidenced by the numerous cases already cited), but also among the highest intellectual circles simply because the sheer entropic nature of all happenings is ignored or misunderstood. Sir Macfarlane Burnet, a Nobelite, in a special lecture considered it imperative "to prevent the progressive destruction of the earth's irreplaceable resources". And a prestigious institution such as the United Nations, in its Declaration on the Human Environment (Stockholm, 1972), repeatedly urged everyone "to improve the environment." Both urgings reflect the fallacy that man can reverse the march of entropy. The truth, however unpleasant, is that the most we can do is to prevent any unnecessary depletion of resources and any unnecessary deterioration of the environment, but without claiming that we know the precise meaning of "unnecessary" in this context.

See the dialogue between Preston Cloud and Roger Revelle quoted in Environment: Resources, Pollution and Society. *Ed. William W. Murdoch, Stamford, Conn. 1971. The same refrain runs through Maddox's complaint against those who point out mankind's limitations.*

To be continued in July

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NATIONAL ECONOMIC PARKS

A brilliant new concept in environmental education is reportedly being prepared for consideration by the coming Governing Council meeting of the UN's Environment Programme. The idea is to create, in every country, a National Economic Park which would be the exact opposite of the ordinary National Park reserved for wildlife and recreation. An Economic Park would be an area where nothing is allowed to interfere with pure economic growth — no pollution controls, no clean air acts, no subsidies for public transport, no zoning or planning controls, no interfering medical health officers — and lots of Fast Breeder Nuclear Reactors.

The first area proposed is Los Angeles, in a plan worked out by Professor Harry S. Cole of Wisconsin (USA). In the September issue of the Bulletin of Atomic Scientists, he suggests a "National Environmental Degradation Act" under which it would be possible to set aside a federally supervised national preserve to be protected from all environmental protection legislation. It would have an Economic Quality Council (EQC) to ensure that economic growth was never disturbed by environmental legislation, and its members would be selected "from the executive ranks of the petroleum industry, the electric utility industry, the automobile industry, the billboard-neon sign industry. . ."

Economic Impact Statements would be required for any proposed controls on noise, radio-activity, pollution, or for any zoning proposals, tree-planting or other sentimental nonsense.

Professor Cole points out the need "to protect the unique social economic and physical conditions found in the Los Angeles basin . . . (it) is a living laboratory, a living museum that should be preserved unspoiled for future generations".

Many other countries are reported to be trying to catch up with the Americans and close the gap. In Japan, there is a strong lobby to preserve Kawasaki City, just outside Tokyo, which is reported to have more chemical piping, flue stacks and bronchitis per square metre than anywhere else in the world. Compared to Los Angeles, however, it is notably lacking in elevated concrete highway.

In the Federal Republic of Germany, there are several proposals, but the one gaining most ground is a place known only to connoisseurs of unbridled industrial enterprise — Wanne-Eickell near Bochum. France already has Maubeuge whose charms by moonlight were celebrated some years ago in a song that was top of the hit parade.

In Britain, it is believed that it may not be too late to save the whole of southeast Lancashire, long thought to be the original homeland of industrial man and where coal-fired steam locomotives first went into service. Although the effects of clean air legislation have affected many parts of Britain, there are known to be areas almost completely untouched, but their whereabouts are kept a close secret from the environmentalists. Many other countries are studying suitable areas but have not yet reported.

There is a good deal of controversy on the social and financial aspects of setting up Economic Parks. Evidently, environmental agitators already resident in the areas will have to be persuaded to leave by being given such inducements as country cottages. The Economic Parks themselves will have to keep strict accounts, so that everyone will be able to use them as a reference mark against which to measure the economic impact on other areas badly afflicted by environmental agitation. Still further in the future is the development of a tourist infrastructure to permit outsiders to come along, absorb the atmosphere and study the natives. An Economic Park Warden Service comprised of experienced accountants and economists is also under discussion. What is now needed is co-ordination at the international level — another job for the United Nations.

Reprinted from Developement Forum April 1975

Report

CORGI OR WATCHDOG!

There is a celebrated *Punch* cartoon in which a young curate, breakfasting with his Lord Bishop, is asked whether his egg is bad. His classically tactful assurance that parts of it are excellent closely catches the ambiguous flavour of the fourth report from the Royal Commission on Environmental Pollution.

As usual, the report is submitted with a courtly flourish 'to The Queen's Most Excellent Majesty', but reading of the introduction soon reveals confusion. Thus, on page 2, the Commission commendably sees its role 'as a watchdog body', but then goes on to state that 'we shall not normally need to concern ourselves with immediate problems that demand urgent action'. What sort of Queen's watchdog is this that will not bark at intruders already on the premises? Can such a beast be worth its bones?

To be fair, confusions such as this are probably inevitable when scientific problems have to be reviewed in an essentially political context. Science and politics operate from different ethical bases: one concerns factual knowledge as an approach to truth, whereas the other is the art of manipulating opinion. In this report, the Commission has sought to emulsify the water of science with the oil of politics, but the apparently homogeneous result is still recognizable as a two phase system.

The report is probably more successful as a political than a scientific document. Nontechnical readers will appreciate the mostly clear and occasionally stylish presentation, the comparative absence of scientific jargon, the evidence that numerous scientific studies on pollution are in progress, and the emphasis given to such familiar matters as land dereliction, refuse disposal and the growth of traffic noise (but has the Commission noticed a slight recent trouble over petroleum supplies in accepting predictions of the future growth of road traffic?). Whitehall will probably appreciate the generally mild tenor and the failure to identify any serious problems requiring urgent and expensive action; but the report does question the doctrine that industrial polluters are entitled to secrecy on trade grounds. Its economic views appear to be muddled. Thus on page 6, the report urges that economic or short term arguments to justify further deterioration of the environment 'should be strongly resisted', but on page 79 it calls for an expansion of economic studies 'so that the economic effects of changes in pollution standards may be appreciated before decisions are taken'.

Professional scientists may doubt whether 53 cited references (of which only some 13 are to papers published in scientific and medical journals) could possibly provide adequate and balanced coverage of such a wide field. *The report is indeed a grossly incomplete and selective compilation, and one or two of the allusions may even confuse more than they clarify.*

The coverage of individual pollutants is strangely uneven. For example, the report has interesting things to say on such varied topics as asbestos, possible effects of freons on ozone concentrations in the upper atmosphere, and of increased dissolution of CO_2 in seawater on shellfish, rising nitrate levels in some rivers (but the attempt to exonerate artificial fertilizers as a major source is unconvincing in the absence of quoted information on the dynamics of transport of soluble nutrients from fields to rivers), pollution from animal husbandry, environmental effects of offshore oil production, and reduction of pollution by reclamation and recycling of metals, glass, paper and plastics. The dismissal of vinyl chloride as a serious hazard to the general public is probably justified, but heavy exposure in industry may well be another matter. (The Commission reports that concentrations in air near industrial autoclaves can occasionally reach 1000 ppm: we have measured levels up to 50,000 ppm.) The maximum time-weighted mean level of 25 ppm recently accepted for the UK compares with 1 ppm for the US and Scandinavia!

I was pleased to see that the Commission is concerned with environmental hazards which may follow expansion of the nuclear power industry, and that a further enquiry is now in progress. Critical group techniques are employed to monitor radiation hazards, and the report properly calls for their use to be extended to other pollutants.

There are some surprising omissions, e.g. polychlorinated biphenyls, Vapona, atmospheric NO_x levels in the UK, herbicides. An apparent discrepancy between CO levels (greater than 30 ppm averaged over the working day) measured by the GLC on Putney Bridge and the much lower levels previously

reported by the Department of Industry's Warren Spring Laboratory from a survey in six cities reminds one that the Warren Spring national survey data supposedly indicating declining SO_2 and smoke levels were described as 'atypical and misleading' following a BSSRS survey (see B. Imrie *New Scientist* 1973 4 Jan p.10).

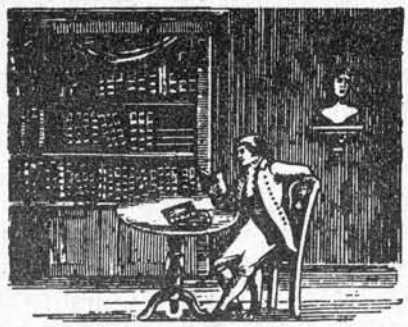
In this connection it is instructive to contrast the correlations between total emissions and ground level concentrations of smoke and SO_2 depicted on pages 12 and 13 of the report: there may be more to this matter than high chimneys. Table 1, p.14, conveys the impression that it may not be as necessary as once thought to control SO_2 emissions when smoke levels are only approximately 200 μgm^{-3}, but references (not given) to US air quality control standards, Professor Lawther's studies, or the BSSRS survey in Leeds would strongly qualify such a conclusion. The emission of SO_2 is a politically sensitive topic, and although the Commission handles it gingerly, one may infer that the health hazard is still very real.

Of toxic heavy metal pollutants, cadmium and mercury, which do not appear at present to pose a general major hazard in the UK (except perhaps to eaters of crabs and inshore fish) are discussed with reasonable objectivity. In contrast, the enormously greater hazard from lead which on present evidence places millions at risk, especially city children, receives a smoothly superficial treatment, strongly biased towards complacency, with special pleading about the cost of petrol, false innuendo that dealing with the problem of airborne lead might increase the levels of 'more serious' pollutants, and slyly selective citation (thus the controversial reference 46 is mentioned without reference to the strongly critical comments from a number of other workers published in *The Lancet*, or to the contrary findings reported from the USA). The imbalance here is only partly redeemed by passing reference to Dr Hicks' admirable but already partly outdated review on airborne lead, and the ritual call for more research. Those who consider this judgment harsh might like to contrast the present report's treatment of lead pollution with the forthright official statements and reports on the same subject published by the US National Academy of Sciences and, more recently, the US Environmental Protection Agency (see e.g. *Federal Register* 1973, 38 (234) 33734).

Appendix B of the present report lists sources of information on pollution, but does not include the Conservation Society, Friends of the Earth or BSSRS. The reader seeking further information on lead, for example, is obligingly referred to Associated Octel, the manufacturers of alkyl-lead petrol additives. In the same spirit, I shall be happy to supply the name and address of a good brewery to anyone seeking information on alcoholism.

D. Bryce-Smith

Report – Corgi or Watchdog – Reprinted from Physics Bulletin February 1975



Books

Lessons we Refuse to Learn

TOPSOIL AND CIVILIZATION by Vernon Gill Carter and Tom Dale. University of Oklahoma Press Revised Edition, 1974. $7.95.

This book deals with the most important problem which man has had to face since the Neolithic Revolution, and the one which has attracted the least attention: soil erosion. It tells the tragic tale of how succeeding urban civilizations have systematically deprived their land of its topsoil by deforestation, over-cropping and over-grazing with armies of sheep and goats; how they waged an unequal struggle against the silt accumulating in their waterways, their harbours and their irrigation canals, and how once the land was deprived of its fertility they moved away to greener pastures.

Carter and Dale relate how, in this manner, the inhabited areas of the world have been and are being transformed into deserts.

The historical records of the last six thousand years show that civilized man ". . . was never able to continue a progressive civilization in one locality for more than thirty to seventy generations (800 - 2,000 years)." There are three notable exceptions:— the Nile Valley, Mesopotamia, and the valley of the Indus. The average life span of civilizations was forty to sixty generations (1,000 to 1,500 years). "In most cases, however, the more brilliant the civilization, the shorter was its progressive existence. These civilizations declined in the same geographical areas that had nurtured them, mainly because man himself despoiled or ruined the environments that helped him to develop his civilizations."

The civilizations of Mesopotamia and the Indus Valley lasted a bit longer as conditions were more favourable. Nevertheless, today, where there were once the various cities of Sumeria and Babylon, Ninevah, Mohenjo, Daro and Harappa, there are now deserts. Egypt was the most fortunate, since every year the Nile flooded and spread out over the adjoining land vast quantities of silt brought down from the highlands of Ethiopia.

The greatest tragedy of all, however, is that we have not learnt from the experience of the past. Modern agriculture is incredibly destructive and the modern world is losing its topsoil at a terrifying rate.

What does the future hold in store for the United States which is fast becoming the granary of the world?

According to the 1970 Year Book of Agriculture, almost two thirds of the U.S.'s present arable and privately-owned grazing land, and more than three fifths of private forest and woodland, needs conservation treatment.

According to Carter and Dale, fifty million acres of arable land are eroding at a "highly accelerated rate". Within twenty five years they will have been lost to agriculture. Another fifty million acres will have been taken over for urban uses. This represents a quarter of America's agricultural potential. How does one react to these terrifying facts?

If one considers that by that time, the population of the U.S. will have increased by fifty per cent, it doesn't appear that there will be very much grain available for export. This is particularly serious since seventy-five per cent of the world's grain imports at present come from the U.S. It is indeed frightening to consider that our leaders still have no qualms in allowing us to remain dependent, for our sustenance, on imported food supplies.

If one looks a little further, a hundred years or so, then the U.S. will be in the same situation as all other previous civilizations once they had completely wiped out their topsoil. They will have to seek greener pastures elsewhere. This time, however, they will have to rely on NASA to locate them, and on a miracle to provide them with fuel to transport them there.

This is an excellent book, it is the first I have come across which really describes the impact of early civilizations on the environment; thus it fulfils a much felt need and should certainly be read by everyone concerned with the problems we deal with in this journal.

Edward Goldsmith

Bringing the Wolf to the Door

LOST BEASTS OF BRITAIN by Anthony Dent, Harrap £2.85.

Britain is singularly poor in its natural fauna. Two great disasters of the last million years have brought about this situation — the Ice Ages and the arrival of *Homo Sapiens.* Of the two, the latter was infinitely more damaging; and the impact of man has always fallen most heavily upon the larger land mammals. Most of the more spectacular Pleistocene fauna were exterminated by man, a fact which is still too little known. The wanton and irrevocable squandering of natural resources is not a modern phenomenon, but a human characteristic in all periods.

Anthony Dent's book is concerned with the tail-end of this process — it tells the story of those animals which have become extinct in Britain (or, in the case of the wild cat, England) in historical times. This is not a detailed, exhaustive survey; reading it is rather like listening in to the High Table conversation in an Oxbridge college — witty, erudite, discursive, spiced with personal anecdote and personal prejudice.

The four main sections of the book are devoted to Beaver, Boar, Wild Cat and Wolf. A prologue deals more briefly with Bear, Wild Cattle, Reindeer and a few others. On the whole, Dent probably errs on the side of caution, concluding, for example, that bears were extinct in Britain by about the 5th century, and that reindeer and aurochs were not found here after the Old Stone Age.

Of Dent's four main subjects,

three were regarded as vermin: one, the beaver, was exterminated because he was *useful.* Beaver fur is excellent for making warm, waterproof hats. Indeed, these hats were in such demand that when we had wiped out our own beavers we seem to have taken over Canada partly in order to ensure a continued supply of furry sou'westers. The wild boar was unpopular because of his depredations in farmland, but even more because he competed directly with domestic pigs in their woodland feeding-grounds. He finally died out in the mid-17th century; had he held out a few years longer he might still be with us, for by then the free-range pigs of the Middle Ages were increasingly becoming confined to sty or farmyard. The boar might well have survived, as deer did, under the protection of rich landowners. Could not the huntin' and shootin' fraternity be persuaded to re-establish him as a game animal? True, boar-hunting, as Dent makes plain, was no sport for cissies – but it was probably no more dangerous than plenty of popular modern activities such as motoring!

The wolf and cat were wiped out because their interests clashed with those of sheep-farmers. "It is hard to imagine", says Dent, "the weight that was lifted from the flock-master's shoulders once the wolf was no more. Like being in the dairy business and waking up one morning with the assurance that there would never be another outbreak of foot-and-mouth or contagious abortion – never again." We should remember this when we think about the problems of wild-life conservation elsewhere in the world. Indians whom we urge to preserve their few remaining tigers can reasonably retort that we took good care to eliminate *our* larger carnivores a long time ago. If we really want to practise what we preach, I suggest the reintroduction of the wolf as a first step. In my own county, Sussex, wild deer have increased to such an extent that they have to be regularly "culled"; a few wolves would do the job much more efficiently, besides adding new interest to rambles on the South Downs!

Nicholas Gould

Digging for Survival

THE NEW VEGETABLE GROWER'S HANDBOOK by Arthur J. Simons, rewritten by Brian Furner. Penguin 75p.
BASIC GARDENING by Alan Gemmel, Penguin 60p.

Dig for Survival? It may come to that and whether it does or not, as food prices rise faster than most of our wages, large numbers of people have taken to digging as though their lives depended on it. In many parts of the country the supply of allotments cannot meet the demand and seed firms are finding it difficult to keep the shelves stocked at sowing time. Publishers are not slow to satisfy demand for instruction, however, and in February Penguins produced two more titles for the amateur gardener.

The New Vegetable Grower's Handbook is a re-worked edition of the original 1942 *Vegetable Grower's Handbook*, written by Arthur J. Simons while he was quarantined because of childish infections he contracted during air raids, and published at the height of the Dig-for-Victory campaign. It is a straightforward, simple but very comprehensive account of all the beginner needs to know about every vegetable you ever heard of – and probably one or two you didn't. It proceeds from vegetable to vegetable, in alphabetical order, from artichokes to turnips.

It has been rewritten by Brian Furner, and this has brought some changes. The wartime book was published in two volumes, the first dealing with soil preparation and management – including digging up grassland – and the second with the crops themselves. The new version consists of the second volume only, expanded now to one a half times the length of the original. The expansion is a direct result of employing Brian Furner to rewrite it, for if a plant can be grown and eaten, Mr. Furner will grow and eat it. I remember him once complaining of a shortage of dandelion seed! So, along with the cabbages and peas you will find okra, hamburg parsley and capsicums although strangely enough he describes only one variety of mint. The first part of Mr. Simon's due is replaced by Alan Gemmell's *Basic Gardening.* Prof. Gemmell writes for the beginner faced for the first time with the waterlogged battle-ground surrounding his new home, and he explains plainly and simply how to cope. Much of the book is devoted to ornamental gardening, although there are chapters on vegetables and fruit as well as one on house plants – omitted from most gardening books.

The books complement one another. *The New Vegetable Grower's Handbook*, with 352 pages, costs 75p and *Basic Gardening*, with 270 pages, costs 60p. So for an outlay of £1.35 the would-be amateur gardener is assured of a sound start. At today's prices you will find no better value.

Michael Allaby

You Have Been Warned

YOUR DAILY FOOD: *Recipe for Survival,* Doris Grant, Faber & Faber 1974. 207pp. £2.25.

The hundreds of thousands of unenlightened shoppers who fill their baskets with chemicalized unbalanced mixtures, rich in residues of pesticides, fungicides and detergents, toxic metals, nitrates, penicillin and other antibiotics and Uncle Tom Hormones and all, with a sprinkling of radioisotopes for good measure, which pass for food in this age of permissive pollution by additives, should all be persuaded to read this book. *It is written for them.* Not for that minority of us who have rejected for years all pre-cooked, ready-to-serve convenience foods as bound (in the interests of profit) to be low in necessary nutrients and high in unwanted and often harmful substitutes and extras. This book, by a well-known and respected writer on nutrition, sets out the plain and well documented facts about our food today which millions ought to know but are unaware of.

It is time all food innocents learned the facts of life about food. For far too long attention has been focussed on educating us about sex while food has been wholly neglected as a subject deserving study and

attention. Few question today that good sex education is a *good thing.* But a far, far better thing would be good education in food values and above all on food non-values. Who today wants to waste money on foods which force any number of potentially and actually harmful ingredients on our unfortunate digestions? Of course this boosts the sale of indigestion tablets and laxatives etc., but contributes little to the health or happiness of ordinary people.

Doris Grant, in her latest book *Your Daily Food,* written some 30 years after her *Your Daily Bread,* makes an important contribution to this much needed education. She not only puts us wise to the many chemical tricks which substitute for honest nutrients in the much advertised goods filling the shelves of bakers, grocers, etc., but draws attention to the increasing emphasis in medical journals on the importance for health of properly constituted food and tells us how and where to ensure getting this.

As a pendant to *Blueprint for Survival* (*Ecologist*, January 1972 and after) this book, sub-titled *Recipe for Survival,* should find a place on every bookcase. It teems with information just asking to be quoted in reply to such usual and plaintive questions as "But surely 'enriched' white bread must be better for us than mere wholemeal bread?" or that other most topical of queries, "Do you mean to say I can overcome constipation without spending so many precious pence every week on laxatives?"

There must be others like myself, convinced many years ago of the need to improve the daily bread of our families, who are already in debt to Mrs. Grant. Is she not the "onlie begetter" of the *Grant* (no kneading needed) *loaf,* which has lightened the workload of so many of us home-made wholemeal bread bakers, and saved us from producing those beads of perspiration on the brow which William Cobbett found so alluring?

She has put us all in her debt again by pointing a very well-informed accusing finger at many practices in the food production business which are less than defensible and may be dangerous.

Hilda Cherry Hills

This months authors

Nicholas Georgescu-Roegen was born in Rumania and educated at the University of Bucharest, the Sorbonne and University College London. He is now Distinguished Professor of Economics at Vanderbilt University in the U.S.A.

S. P. Dhua is Director of the Fertilizer Corporation of India Ltd.

Joanne Bower is a founder member and Hon. Secretary of the Farm and Food Society. She comes of farming stock and serves on the Scientific Development and Animal Welfare Committees of the National Council of Women.

D. Bryce-Smith B.Sc., Ph.D., D.Sc., F.R.I.C.S., is Professor of chemistry at Reading University, Chairman of the European Chemical Association and Vice Chairman of the U.K. Solar Energy Society. His academic interests include all aspects of the applied sciences on society.

Also Received:

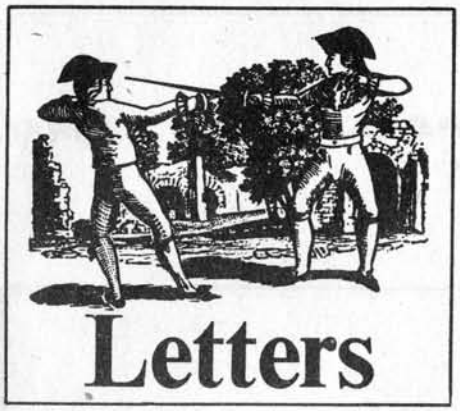
VEGETABLES: Growing and Cooking the Natural Way W. E. Sherwell-Cooper. 219pp. Illustrated in black and white. Published by George Allen & Unwin.
Hardback £5.75. Paperback £3.00.

Handicap of a Hooked Beak

BIRDS OF PREY IN EUROPE, by Maarten Bijleveld, Macmillan, £12.50.

One of the difficulties in making any historical assessment of the numbers of wild animals is the lack, until quite recent years, of any precise data. So, in his review of the decline and fall of the *Birds of Prey in Europe* Maarten Bijleveld is faced with phrases like 'tens of thousands' and 'unimaginably numerous' as the impressions of nineteenth century observers. But there can be no doubt about the broad outlines. As the passion for game preservation and the efficiency of firearms increased, so the number of the 37 diurnal European birds of prey, went down until the two world wars (especially the second) gave them respite while their persecutors destroyed each other. By 1950 the situation of nearly all the 'hook-beaks' looked quite favourable; then came the biocide invasion of the countryside, accompanied by other human pressures, and the slide was on again. It is remarkable that none of the 37 has yet ceased to breed in Europe. After a survey of the position country by country and species by species, Dr. Bijleveld summarises first national legislation, still largely honoured in the breach, and then possible conservation measures and incentives: rewards for nests successfully guarded, special reserves, the establishment of feeding stations for vultures (which have suffered from the improvement in European hygiene), reintroductions, nestboxes and artificial eyries, the protection of game farms by hollow glass balls which apparently deter most predators, legal action, education and concerted international efforts. It is a pity, especially in view of the high price of the book, that most of the text was completed in 1971, because this is an area of constant change and some of the British information is already out of date. But, as a whole, the compilation is an admirable and necessary achievement.

Bruce Campbell



Letters

Conservation and Tasmanian Politics

Dear Sir,

As State Secretary of the United Tasmania Group I wish to point out some errors in your February issue of *The Ecologist*, in the article entitled 'Some Observations on The Australian Environmental Scene'.

1. Our party is The United Tasmania Group (U.T.G.) and not *Party* as reported in the article.
2. The article repeatedly asserts that some of Australia's conservation issues are "bedevilled by constitutional difficulties" – this is the point of view of the Australia Party, a party that has the pretence of being concerned about conservation.
3. The Australia Party is *not* the only party that espouses the steady-state economy and Z.P.G. In fact the U.T.G. has been doing this since before the Australia Party was even aware of these two concepts.
4. The U.T.G. is contesting its *fourth* elections at the moment.

The U.T.G. was formed on 23rd March 1972, making it the world's first conservation-based political party, as far as we know. One of our major aims is to set up Tasmania as a 'social experiment' involving a steady-state economy, greater material independence, and experimenting in alternative technology, labour intensive industry, organic farming, total re-cycling systems, low energy housing, increased public transport and energy-orientated budgeting. In this way we would hope that Tasmania could become an example of alternative life support systems.

The biggest issues likely to arise in Australia with strong campaigning are:

1. Uranium mining and nuclear energy development – Australia has a moral duty to discontinue uranium mining and export activities.
2. Woodchipping of forests – In Tasmania alone three-quarters of the State has been allocated to woodchipping – the quickest and surest way of destroying our forest heritage – and is being supported, hand in hand, by the Government Forestry Departments and woodchip companies throughout Australia.
3. The South West of Tasmania. This is the last remaining temperate wilderness *in the world.* The recent Tasmanian Minister for National Parks, Mr. Miller, showed no concern about it, and became the target for bitter attacks from conservationists.

Mr. Miller has now been appointed both Attorney General *and* Minister for Police. We must now have a campaign to save the very concept of democracy itself, not that it isn't already in a bad state in Tasmania (we don't even have a Hansard). But how, for example, does an *Attorney General* handle a complaint involving the police, without prejudice, for or against, the Minister for Police, when the same man inhabits both positions?

We owe the articulation of many of our policies to *The Ecologist.* Many thanks and keep up the good work.

Yours faithfully
Geoff Holloway,
State Secretary U.T.G.,
Glenorchy,
Tasmania.

Where Is the Nitty Gritty?

Dear Sir,

Much as I applaud the line of argument and basic conclusions set out in the joint report *Will Britain Starve?* (The *Ecologist* Vol. 5. No. 3) it was disappointing to find the recommendations couched in ambiguous terms that absolutely failed to get to the heart of the matter. This is a plea for a down to earth explanation of what is meant by "restructuring of agriculture" and how it is to be achieved. Will this mean an upheaval in land tenure? And at the other end of the scale, what sort of contribution will be required from the average household? Practical advice would be useful too. For example, would it save resources if every family got its eggs from five hens and a cock at the bottom of the garden, rather than a battery system?

Yours faithfully,
Paul Steel,
Low Row,
Yorkshire.

Losing Ground, the discussion paper on which "Will Britain Starve?" was based, is the first of a series of papers we plan to publish. In this one we sought only to analyse the problem and so to demonstrate the need for Britain to produce much more of its own food. The recommendations are vague, because they cover only the most urgent and immediate remedies that are made self-evident by the rest of the report. Our work now aims to devise a strategy that would make Britain as near to self-sufficient in food as is possible and then to consider the economic, social and political implications of such a strategy. We will examine all the areas Mr. Steel mentions and many more besides, and explain in some detail what we mean by "restructuring" agriculture.
Michael Allaby

A Desert Defined

Dear Sir,

The otherwise excellent article by Wendy Campbell-Purdie, "Green Belt around the Desert" (Ecologist October 1974), is spoiled by failure to define what the author means by desert and Sahara.

Bou Saada is not in the desert. According to the UNESCO/FAO Bioclimatic map of the Mediterranean region it lies in the less dry of the two "sub-desertic" zones where the number of physiologically dry days lies between 200 and 250 per annum. For comparison the "True Desert" suffers from 355 to 365 physiologically dry days and the "Desert" 300 to 355. I have visited Bou Saada and am not relying entirely on that map.

It is good news that enlightened human action is now beginning to

undo the harm caused by unenlightened human action; for instance dry farming in areas where the high variability of rainfall invites frequent disaster, or putting onto marginal grazing lands more animals than the range can carry without being destroyed. But it is misleading to imply that "There is more than enough water underlying the Sahara to reafforest the *whole* area" (emphasis added) since readers will equate the whole area with the whole Sahara (some 10 million square kilometres).

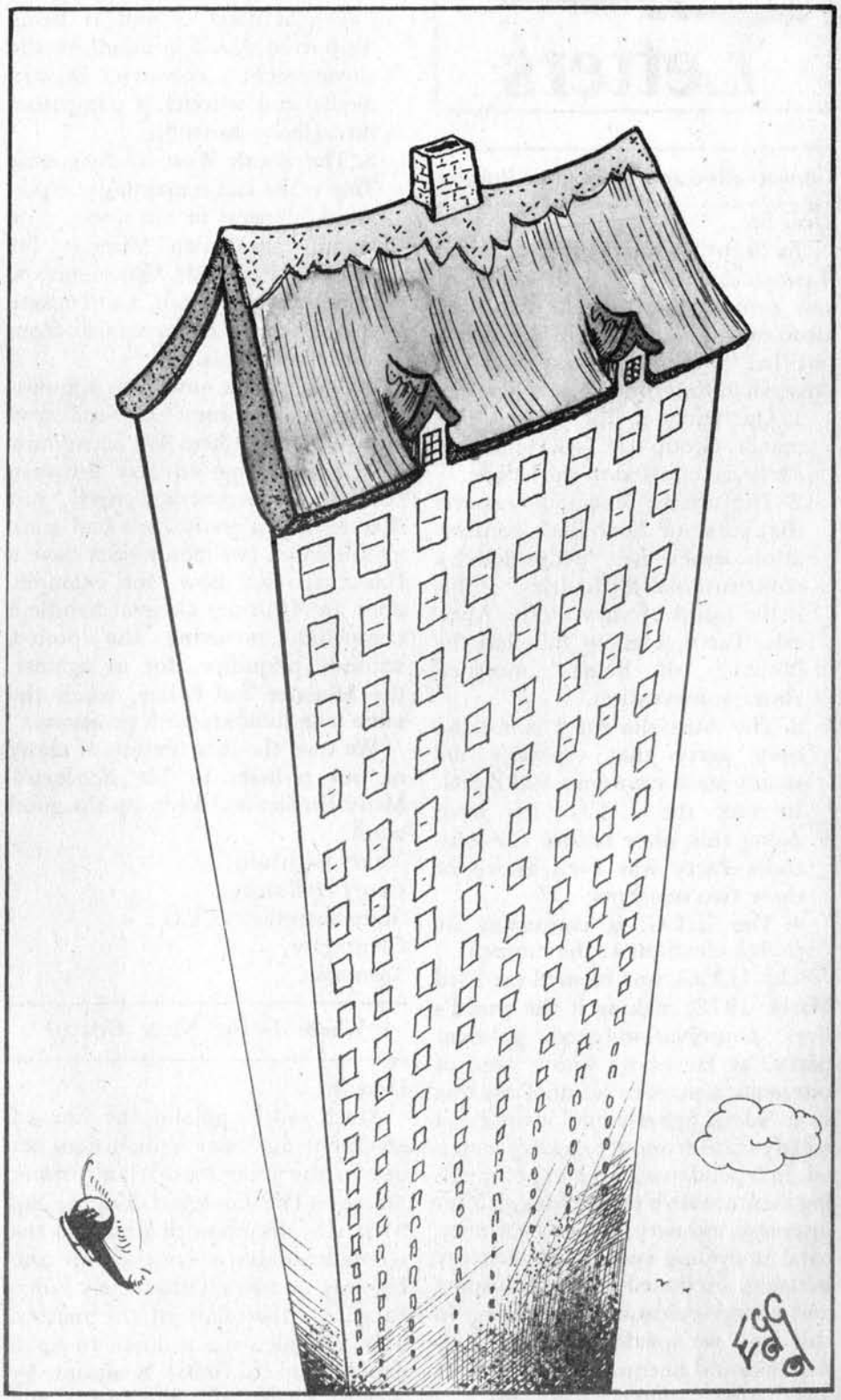
Bou Saada is in a transition area on the northern sub-desertic margin which corresponds with the Sahel of the southern sub-desertic margin but differs from it mainly in being much narrower, in having winter instead of summer rainfall, different insolation (due to latitude differences), etc.

Most of the African countries mentioned in the article are in the Sahel belt and these have all suffered recently from varying periods of generally much lower rainfall than normal (not unknown in the past but then probably less disastrous because of less population pressure). Kenya and Tanzania are not in the Sahel zone and nor is the south of Ethiopia; and there is no convincing reason for relating deficient rainfall in these countries to the Sahel drought. There is good reason, however, to believe that unwise land use is the common factor in all the countries.

It is true that vast reserves of water underlie much of the Sahara but the quality is not everywhere known and some parts are certainly brackish. What is more pertinent is that water lying at 1000 to 1500 metres, assuming that the quality is satisfactory for irrigation and drinking water, requires a vast amount of energy for its extraction in significant quantities. If extraction could be done economically (in cost and energy), and where reasonable quality soils exist, there is no reason why irrigation should not be practised but this will only produce trees and grass (or, more productively, food crops) on the relatively tiny areas irrigated.

The "True Desert", "desert" and "sub-desertic" zones are inevitable results of the global atmospheric

"IT'S FOR EUROPEAN ARCHITECTURAL HERITAGE YEAR..."



circulation pattern and it would be a pity for hopes to be raised unjustifiably in regard to them.

Of course anyone familiar with true deserts will realise immediately, from the reference to springs and water from the wadi for irrigation that Bou Saada does not qualify as a desert. It and indeed the whole sub-desert margin north and south need not only tree planting but also firm, intelligent and enforceable policies in regard to land use. Otherwise I fear that the new trees will one day go the way of those that previously existed in parts of the Sahel.

Yours faithfully,
R.L. Raikes,
Rome,
Italy.

A Tax to Destroy Our Trees

Dear Sir,

I write concerning the Capital Transfer Tax and the proposed Wealth Tax. These new forms of taxation will adversely affect the countryside and in particular the tree cover of Britain.

At present the average UK farm holding is twice the size of the EEC equivalent, the Capital Transfer Tax will cause the throwing away of this advantage. Family owned farms will be split up and the countryside fragmented. A peasant farming economy will tend to result. Or alternatively only institutions will be able to invest in agricultural land (since they can avoid the effects of taxation which the death of a landowner has on a farming family); thus farmers will tend still more to become tenants and not owners of their land.

Capital Transfer Tax falls on the net sale proceeds of any felled timber which has been transferred after death and not the value of the timber at death (as with Estate Duty), consequently the profit in timber growing will be reduced considerably. It is thus no longer economically viable to plant or maintain trees and hedgerows. This discouragement of tree planting will cause a derelict forestry to result.

Due to the present paper shortage and cost of imported timber, existing trees may be felled and sold in order to raise money to pay these taxes; for example, on the transfer of an agricultural holding (woodlands are classed as an agricultural property). Timber is a more easily realizable asset to a farmer than the sale of his animal stock.

The Capital Transfer Tax is now on the Statute Book, (at the time of writing), the Wealth Tax is not yet law. These taxes – as currently set up – will discourage tree planting and encourage tree felling with a consequent damaging effect to the rural environment both for visual amenity and ecologically.

Yours faithfully,
Michael A. Hodges,
Christchurch,
Dorset.

Self Sufficiency Diets

Dear Sir,

Though the present World Population doubling rate is 17 years, wages in Britain now double every three years and prices every four Food will therefore price itself off the plates of everyone who cannot force his income upwards at the pace set by coal miners and M.P.s whose proposed 100% rise, the first since 1972, follows this rate of one third every year. It is time that strike enforced pay rises and inflation were included in all computer based forecasts of the future, for without them these forecasts are irrelevant to the world we live in. As an example, allowing for construction time before, and a thousand years of tending the wastes afterwards, nuclear power is impossibly uneconomic for a mere twenty years of useful life.

We are working on self-sufficiency diets from British gardens for those on fixed incomes or pensions, and we probably have a solution to the problem of growing sufficient protein and Vitamin B.12, in Comfrey, a perennial crop which in our climate yields up to 60 tons an acre, but about twice this where the day length is equal near the Equator. The difficulty of making it storeable, palatable human food for *all* countries, for inflation everywhere hits the hungriest hardest, could be solved by a bacteriological process. Have any readers experience of making sauerkraut with cabbage, or access to the bacteria involved? Is there any bacteriologist willing to help humanity by helping us to find a simple do-it-yourself process to convert a profitable pig fodder to directly consumable protein in time to make a real difference to world hunger? There are no grants available, for though increasing subsidies are given to the dramatic arts, research to help the starving is itself starved.

Yours faithfully,
Lawrence D. Hills,
Henry Doubleday Research Association,
Braintree.

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COMMUNITIES

THE GENESIS COMMUNITY is being born. A detailed proposal defining the community will go out in July to between 300 and 500 very carefully chosen people in Europe, the United States and Australasia, all of whom are significant to the project and most of whom have expressed considerable interest in Genesis during the last 12 months. It will be on the strength of this proposal that some of these will come together as founder members of the community at a remarkable gathering in November 1975. Approximately five months later some of us will move to one of two sites (in either New Zealand or Southern Ireland) to start building a new age community such as has not existed before, one providing every imaginable opportunity for human and spiritual growth. Genesis is showing signs of being part commune, part network of people, with locations in Australia, New Zealand, California, Southern Ireland and England. If you are interested in what we are doing, write to us briefly enclosing return postage. We shall ask you to answer a very searching questionnaire before sharing our elaborate plans further. Keep flowing! Keep growing! We love you: The Genesis Community, BM–Genesis, London WC1V 6XX.

COUPLE IN LATE TWENTIES with child, 4, wish to join Community orientated towards organic farming/gardening and children. Some experience growing vegetables, carpentry, milking, house repair. Anywhere considered. Anna & Alan Hale, 1 Park Terrace, Glandyfi, Machynlleth, Powys, Cymru.

PERSONAL

YOUNG FAMILY (29) seek similar to purchase a smallholding with 2 cottages in Devon/Cornwall. Commitment of approx. £10,000 required (Deposit + mortgage) Box No. PD 78.

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YOUNG FARMING COUPLE, capable and experienced, wish to co-operate with someone owning or willing to buy a farm or smallholding to build up joint venture. Box No. PD 79.

LODGER NEEDED by near self-sufficient family with four young children and a hungry mortgage living in Sussex commuter belt. Might suit London worker interested in experiencing a self-sufficient life without commitment. Phone Doug & Jenny Hamon, Wadhurst 3302.

OPPORTUNITIES

AN EXPANDING GROUP using a scientific/rational approach to communal living, loosely based on behavioural psychology, needs skills more than cheque books. If you feel like expanding, write with SAE, Crabapple Community, Middle Ty Brith, Llansantfraid, Powys, SY22 6TE.

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POSITIVELY NO POLLUTION
if you grow your vegetables the Veganic Way (vegetable composting no-digging). All you need to know to produce good looking, fine flavoured crops. Concise Guide 25p, postage extra (letter rate). There's an Association too. Newsletter bi-monthly. Membership £1. Lime Tree Cottage, Beechwood Road, Bartley, Southampton SO4 2LP.

Towards Self-Sufficiency Booklet

Booklet with 60 ideas and recipes for all-plant, truly economic diet. 32p post-free, the Vegan Society, Dept R, 47 Highlands Road, Leatherhead, Surrey.

INDIA – Join the Cotton Revolution and save village life. Illustrated Report by Heinz Edgar Kiewe and Michael Biddulph. Oxford 16pp. 60p.

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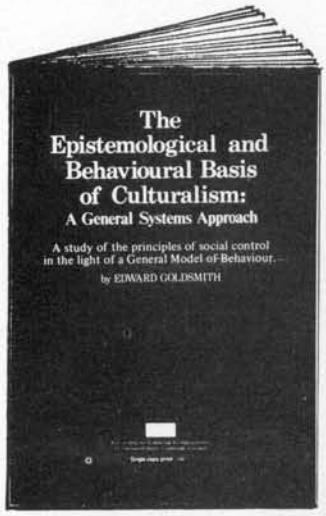

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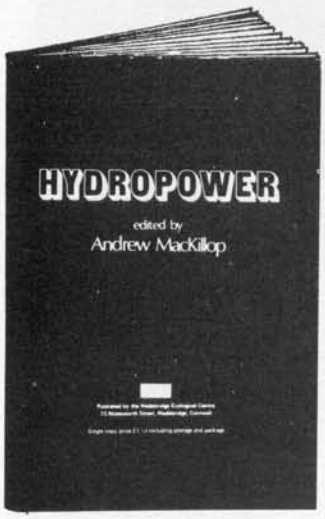

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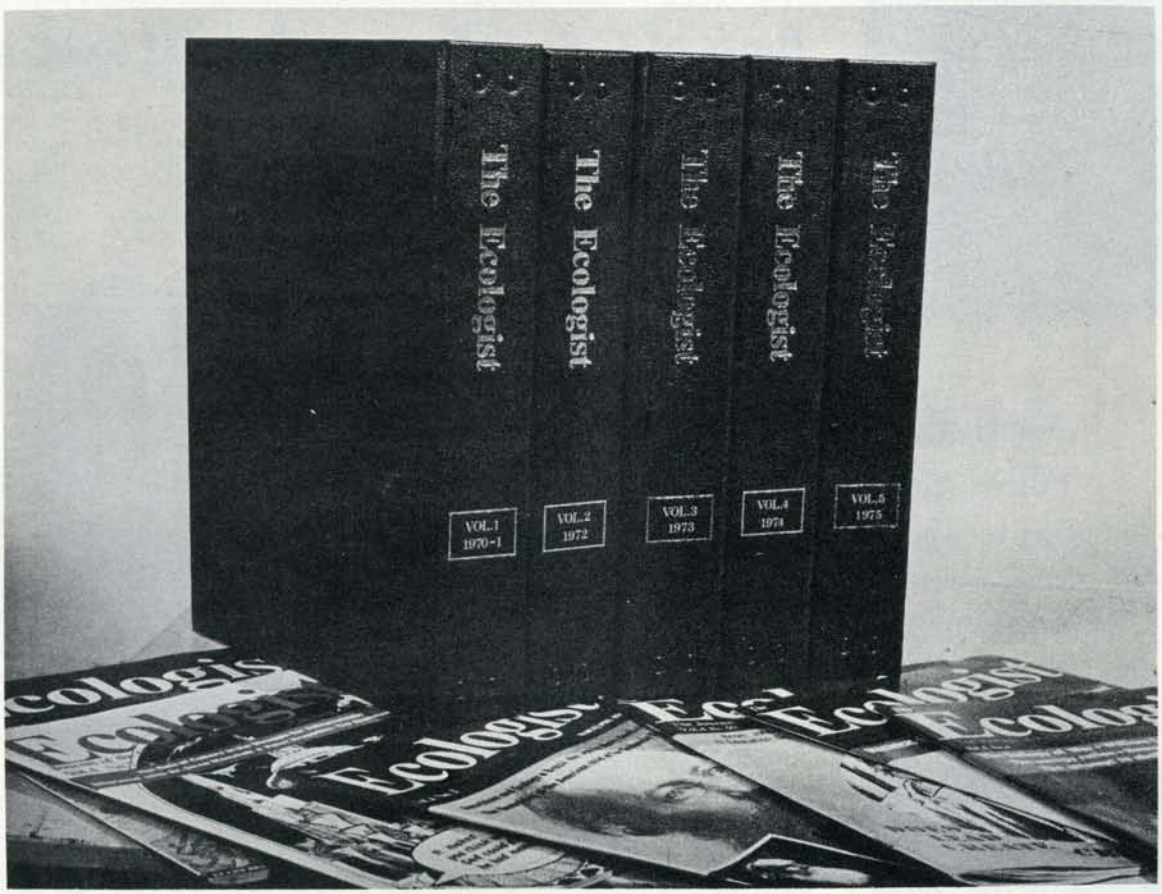

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