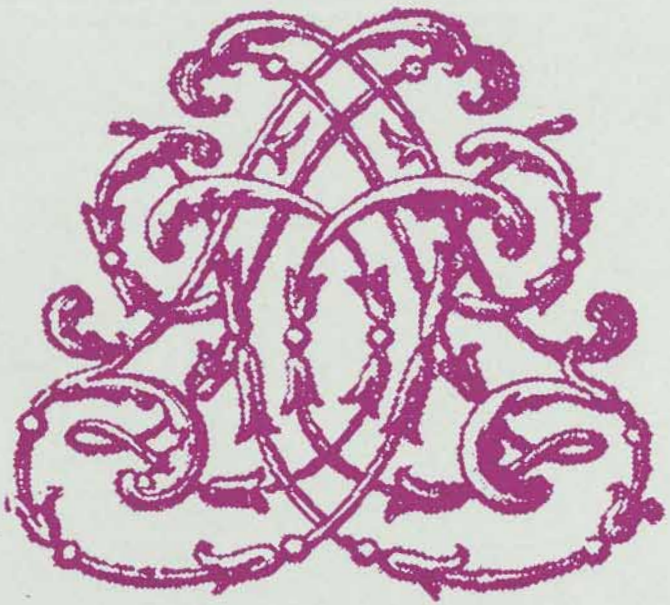
THE ESSEX HALL LECTURE FOR 1971

THE THREAT OF WORLD POLLUTION

Kenneth Mellanby



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This is the Essex Hall Lecture for 1971, and was delivered in Birmingham on 19 April, 1971. Essex Hall is the headquarters of the General Assembly of Unitarian and Free Christian Churches, and stands on the site of the building in which the first avowedly Unitarian congregation met in 1774. The lecture was founded in 1892, and many distinguished men in varied fields have contributed to the series. The delivery of the lecture is one of the leading events during the annual meetings of the Assembly.

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The Lindsey Press, 1-6 Essex Street, London, WC2

Set in Linotype Plantin
Printed by J C Culpin, PO Box 90, Leicester

THE THREAT OF WORLD POLLUTION

DURING the thousands of millions of years of its existence, the earth has undergone many changes. At first it had no atmosphere, then some gases were released from the interior. These were mainly carbon dioxide and water vapour, with a small amount of nitrogen and no free oxygen. The atmosphere's composition changed as the water vapour condensed to form the ocean, and as the carbon dioxide was taken up into carbonate rocks and as a constituent of growing plants. Ultimately some of the carbon was locked up in the fossil fuels produced from this vegetation, and it has remained so stored for millions of years until today, when it is being so prodigally released as man squanders these resources. The oxygen in the atmosphere arose mainly as a result of the photosynthesis which reduced the carbon dioxide levels. Thus throughout geological time the proportions of these gases have varied from epoch to epoch. Our present atmosphere is one stage in this process. So today our globe is surrounded by a mixture of gases, consisting mainly of some four-fifths of nitrogen and one-fifth of oxygen, with other substances at much lower levels. These include the surprisingly small amount of carbon dioxide, only 0.03-0.04 per cent, on which all green plants depend, a varying amount of water vapour, small quantities of helium and other inert gases, and various additions and pollutants arising from man's activities as well as from natural processes.

The world's climate has also undergone changes. The area we know today as Britain has enjoyed periods of tropical warmth and of freezing cold. As recently as ten thousand years ago much of the country was covered with ice, which retreated slowly towards the North Pole as conditions became more temperate. Even in the last thousand years, since the Norman conquest, there have been changes, though not of such a drastic nature, with

comparatively warm spells such as we enjoyed during much of the twentieth century, and cooler periods such as occurred during much of the nineteenth.

We tend to accept the world as it is now, or rather as it was before man had noticeably affected it, as if this was the ideal environment for man and, indeed, for all animal and plant life. We forget that change has always occurred, and is likely to continue to occur, whether or not man dominates the globe. But today we have further causes for alarm. We know that man sometimes produces and releases substances which are harmful to life—that is, pollutants—in quantities which may damage the whole environment. We fear that this may continue and get worse until man destroys himself. We also fear that man's technology may become so powerful that it will upset the whole balance of the various processes which keep the world habitable. The speed of these man-induced changes may be so great that it may be impossible to counteract them in time. It would also be impossible for man, or other forms of life, to adapt as they did to the more gradual global changes during earlier ages when the processes of evolution were at work. Concern at the possible damage to our environment gives rise to the suggestion that this exploitation of our resources is a function of capitalist greed, and that only political changes will produce a proper conservation policy which will save the world from destruction.

However, not everyone takes this view. Technology has clearly brought enormous improvements to the standards of life of many who were previously underprivileged. This gives support to the belief that, properly used, technology could continue to be beneficial rather than harmful to mankind as a whole. The view is expressed that the whole idea of conservation, and the slowing down of technological advance because of hypothetical dangers to the environment, is some sort of fascist plot to prevent the more unfortunate from getting their just rewards. At this point thinking may become somewhat confused, and we may be told that while technology allied to capitalism is a major cause of environmental damage, yet under a different political system it may be entirely beneficent.

My task is to try to give an objective view of this problem. Should we be optimists or pessimists? Is the world becoming a better place for the majority of its inhabitants, or are we likely to destroy ourselves in the near, or distant, future? I shall try to discuss the various dangers in an objective manner, and to distinguish those which are of real importance from those which are not. I hope to avoid making the sort of exaggerated statement so commonly produced today. We have many 'doomsday men' who are no doubt well-meaning, and worried about the future of the world and of man-

kind, but they often do more harm than good. By preaching about our doom with all the sadistic pleasure of the nineteenth century revivalist preaching hell fire, and by devoting so much attention to spectacular and yet unlikely causes of disaster, they may divert attention from the real dangers which could damage our environment permanently. They may, by calling wolf where there is no wolf, actually prevent action against preventable forms of environmental damage.

Before going further, therefore, I must give some definition of what I mean by pollution. I consider that man-made pollution occurs when some activity causes damage, either to man himself, or to the environment. I think that it is important to specify that damage must be done. Today our chemists are able to detect the occurrence of poisonous substances at incredibly low levels, far below those at which any biological effect can be demonstrated. Such cases should not usually be considered to represent 'pollution'. The only exception is in the case of a very stable substance which may be concentrated within a living system from a harmless up to a damaging—a polluting—level. Some examples of this will be described later.

A pollutant may be a poison, or it may be an otherwise beneficial substance present at the wrong concentration. Thus carbon dioxide is necessary for plant growth and so, ultimately, for the continuation of life upon earth. At a high concentration it is poisonous to man and other animals. It is also suggested that an increase in carbon dioxide might alter our climate with drastic and harmful effects on many parts of the world. A further point to be remembered is that pollution is essentially a re-arrangement of substances already present on earth. This may be a physical re-arrangement, as when energy (heat) raises a river above the level where normal life can proceed, or a chemical re-arrangement, where existing atoms are re-combined by man into a poisonous chemical. Eventually most forms of pollution will control themselves as toxic substances are rendered harmless, but this may not happen quickly enough to prevent permanent damage to mankind.

I should like first to deal with some alarming suggestions regarding the possible effects of man's activities on the whole economy of the globe, as carbon dioxide, to which I have just referred, is involved. It is true that we are burning up our stores of fossil fuels, oil and coal, which were laid down over many millions of years, so rapidly that within less than a hundred years they may be exhausted. In this process enormous quantities of carbon dioxide are liberated into the atmosphere. Although the levels of this gas are still very low, there is evidence to suggest that they have risen by about a quarter since the beginning of this century, and with the increased

use of these sources of energy carbon dioxide levels might double by the year 2000. This could be beneficial to agriculture and cause an increase in crop yields. However it might also affect the heat balance of the globe. A rise in the level of atmospheric carbon dioxide might have what is called a 'greenhouse effect' and could trap the energy from the sun, thus causing a rise in the mean temperature of the world. However attractive this might seem to us in Britain, the effect could be to melt the polar ice and raise the level of the oceans, flooding large areas of low-lying land. Some writers have suggested that by the end of this century sea levels could rise as much as 100 feet, and so destroy several of Europe's capital cities. No one can say for certain just what will happen, but in my opinion such a result is most unlikely. On the evidence available today, the effects of burning of fossil fuels, including the enormous consumption by jet aircraft flying at high altitudes, are unlikely to affect the world climate to an extent which is significant in comparison with the natural fluctuations which are likely to occur without man's intervention. Nevertheless it would be foolish to discount this danger altogether, and I hope that we will carefully monitor all changes in global temperatures and air composition, so that if doom is indeed at hand we can take immediate and drastic international action.

It is also suggested that air pollution may be having just the opposite effect, in that industry, by increasing the amount of smoke and soot in the air, is cutting down the amount of solar energy, and cooling the globe. This could cause a new ice age, with a falling of sea levels. This again is a supposition which receives little informed support; monitoring should give a warning before changes in climate had gone too far.

Another suggestion sometimes put forward is that we are in danger of using up the oxygen in the atmosphere, or of not renewing it because we are destroying our forests and the phytoplankton in the oceans, and so we will be destroyed by asphyxiation. This is a long-term possibility, but careful calculations suggest that even with the most serious reductions in oxygen renewal there is a sufficient store in the atmosphere to last for several hundred years. The risks of genuine pollutants making the air unbreathable are far greater than the risks of oxygen deficiency.

Thus I do not believe that we are in imminent danger of global catastrophe from heat, cold or an exhaustion of our atmospheric oxygen. Nevertheless there are real dangers to mankind and to his environment from atmospheric pollution.

In the nineteenth century, great harm was done by the smoke and poisonous gas produced from our 'dark satanic mills'. There was much truth

in the saying 'where there's muck there's brass'. Profits were greater because money was not spent on the control of pollution. When the first Alkali Act was passed just over a hundred years ago, many industrialists said they would be ruined, and some in fact were. This and subsequent legislation, including the Clean Air Acts, has had the result that the air in Britain today is cleaner that it has been for a very long time. The improvements in London and Birmingham and many of our cities are enormous. The smog which in 1952 caused so many thousands of deaths among elderly people and bronchitic patients in London is believed to be a thing of the past, and the authorities are cleaning the stone of buildings like St Paul's Cathedral, in the hope that they will remain in that condition for many years. The improvement is unfortunately patchy. Many of our northern towns show much less improvement, and today the old saying could be paraphrased to 'where there's muck there's poverty'. The dirt in the air comes mainly from older and sub-standard housing where raw coal is still burned. We need a national effort and the spending of much more money to raise our standards to those of London throughout the country.

Smoke, one of the most harmful pollutants of the air, is then decreasing in Britain, and by an effort could be reduced even more. Whether it will be so well controlled when industries get under way in the undeveloped parts of the world is doubtful, and we may once again see smoke levels rising where technology could prevent this damage. But in the long run, man should be able to control his smoke. Unfortunately other forms of air pollution may be more difficult to prevent. Sulphur dioxide is produced when oil or coal are burned, and in Britain we still pour some six million tons of this gas into the atmosphere every year. Sulphur dioxide, when present in sufficient quantities, is toxic to man and to plants.

Fortunately, though emissions continue, the ground level concentrations in our cities are falling, because much of the gas is now blown up into the upper atmosphere by higher and higher chimneys. Under favourable circumstances this is a perfectly good method of disposal, for sulphur dioxide is combined in a matter of hours, or at most of days, into much less toxic substances. It is not normally a long term pollutant.

Nevertheless I am not satisfied with the situation. We know that, though man may not show symptoms of damage, vegetation is harmed by the existing levels of sulphur in the air of our towns. Such plants as lichens are absent from our city centres, and coniferous trees do not thrive in the Pennines, probably because of the sulphur from industrial Lancashire. We are beginning to recognise damage in agricultural crops at quite a distance

from industrial areas. World levels of atmospheric sulphur are beginning to rise. It is still true that more than half the atmospheric sulphur comes from natural sources, such as decomposition in swamps and gases from volcanoes, but this 'natural pollution' is not necessarily harmless, and should not be added to. Here again the danger is that new industries in developing countries may add to the problem before adequate methods of control can be introduced. International organisations which give aid to help to introduce these industries should be more conscious of the possible damage that may occur, and include provision for pollution control in their schemes.

Many people think that the motor car is the greatest danger to our atmosphere. It is true that in parts of North America the poisonous gases from car exhausts produce the very toxic 'photochemical smog' which is notorious in California. This is a serious problem, but within a few years it will be controlled by the stringent legislation now being enacted in the United States. In Britain car exhausts are a nuisance, but we never suffer as they do in California. I think that there is little doubt that we will soon follow the lead of America and insist on our cars being modified to reduce air pollution. This will obviously be a good thing, even if, under British conditions, it could be given a lower priority than it is likely to receive. It is a great temptation to the authorities to take some concrete action of this kind, so as to be able to demonstrate their concern, when other forms of pollution which are in fact more dangerous go unchecked.

As far as Britain is concerned, I think that we have reason to be optimistic about our air. It is cleaner today in our cities than it has been for a hundred years. The rate of improvement is not fast enough, and greater efforts are needed, but we should at least keep up with the effects of industrial growth. In the rest of the world the situation is not so rosy, and serious global air pollution may occur as populations rise and industry spreads. This could be prevented, but only by international co-operation and control.

Before leaving air pollution, I must briefly mention the one really serious pollutant that harms man—tobacco smoke. I have been criticised at public meetings by questioners who have accused me of being unduly optimistic about smog or the effects of car exhausts, while the questioner has been puffing away at a cigarette. There is no doubt that in Britain today, smoking produces a much more serious effect on man than all other forms of air pollution put together. If we can be so foolish as to pollute ourselves in this way, have we the right to expect others to control less dangerous forms of air pollution?

A great many of our wastes are deliberately dumped into water, both fresh

water rivers and lakes, and into the sea. Before man became so numerous, this caused little damage. His excrements broke down and liberated their nutrients, which were recycled through plants and animals without doing any ecological damage. However, a situation was soon reached where the system, at least in the rivers and lakes, was overloaded, and it became grossly polluted. A hundred years ago the Thames passing through London was simply an open sewer, almost devoid of life. Since then we have learned to purify our sewage, by processes which in essence accelerate the biological cycling which goes on naturally until overloaded. As a result there has been a great improvement in the condition of inland waters in Britain. The Thames is nothing like the pure salmon river it was five hundred years ago, but it has been reinvaded by some twenty species of coarse fish. Not all our industrial rivers have been improved so much, but, notwithstanding the growth of population and the increase in industrial production, every major river is at least a little less polluted than it was twenty years ago. There is no technological reason why every river in Britain should not, within ten years, be at least as clean as the Thames in London.

However, even this improvement is only relative. The rivers will be pure enough so that, after treatment, they can be used again for drinking and other domestic uses. They will be considered as 'unpolluted' by the water authorities, but, to the ecologist, they will still have suffered degradation. This is partly because though our systems of sewage treatment remove most of the organic matter (which otherwise absorbs the oxygen and encourages bacterial and fungal growth at the expense of fish, insects and higher plants) the nutrient salts, nitrates and phosphates, remain. These nutrients are essential for plant life, but in too high concentrations, such as may be found in sewage effluents, they cause over-nutrition or 'eutrophication', which is one of the most difficult forms of pollution to control. Some degree of eutrophication occurs naturally, as a river flows from the mountains to the plains, picking up nutrients leached out of the land through which it flows. Here a balance is achieved without ecological harm. Man-made eutrophication is much more rapid and drastic, causing unwanted algal growth with subsequent deoxygenation and the death of fish and other animals. This could all be avoided, but at a great cost, by introducing tertiary sewage treatment and removing the nutrients. In Britain we could do this if we were prepared to divert some thousands of millions of pounds to this end. On a world scale, I am less hopeful. I think that gross freshwater pollution will be controlled by the more advanced countries, notwithstanding the terrible state of some North American lakes, but I fear

that industrial and urban development in the less advanced territories is likely to be accompanied, at least for a time, by all the horrors of gross water pollution. Here is another field where international aid should contain some element to obviate these side effects of industrialisation.

Our towns and our factories are polluting our rivers, but this is being, to some extent, controlled. Unfortunately at the same time agriculture is having an increasingly harmful effect. In the past the excrement of farm animals, as manure, was the means of maintaining soil fertility. Today much of the manure is a potential pollutant, no longer being spread by factory farmers keeping their stock indoors with no other land on which to grow arable crops. At the same time the arable farmer may have no stock to produce manure, and no labour to spread it even if it is available. As a result he uses even greater amounts of inorganic fertilisers. These developments all contribute to losses of nutrients from the land, with further eutrophication of our rivers and lakes. The trouble here is that we have a developing pattern of agriculture which is likely to increase water pollution even further. If this pattern spreads further into other countries (it already exists in many) then inland water pollution, based on eutrophication, will become even more serious. This process will only be reversed by a change over to mixed farming or to some other ecologically based agricultural system.

The oceans have long been looked upon as a limitless dump for wastes of all kinds. They could indeed absorb a vast amount of sewage, and recycle the nutrients with benefit to the plant growth and to international fisheries. Unfortunately the largest amounts of wastes have sometimes been discharged into partially isolated seas like the Baltic, with disastrous results to their ecology. But even the open ocean may eventually be too small to cope with toxic wastes which do not rapidly break down to harmless residues, and which may be re-concentrated up to levels at which they can truly be considered as pollutants.

The first group of chemicals which includes substances with these properties is the pesticides. Insecticides, herbicides and fungicides are all used to control organisms—pests—which are considered harmful by man. Ecologists have always been worried by their use, and by the possibility of unwanted and harmful side-effects. However, it must also be realised that modern pesticides have had enormously beneficial effects. Millions of men who would have died from malaria and other insect-borne diseases are alive today because of the use of DDT. Modern agriculture depends on these chemicals. Particularly in the tropics yields have often been doubled when chemicals have controlled pest insects. In Britain herbicides have made

possible the great increase in productivity of arable farmers with a rapidly falling labour force. Unfortunately this is only one side of the picture. When used improperly and in excessive amounts, pesticides have damaged both man and his environment. Much of this damage can be avoided by careful application of the chemicals. Thus in Britain most weedkillers used in cereal crops do only what they are intended to do—they kill the weeds within the area sown. If sprayed carelessly or, against the maker's instructions, in a high wind, spray drift can harm hedges, road verges and nearby gardens, but this is a case of misuse. Most herbicides are not persistent chemicals which escape from the area of application into the environment; they do their job, then decompose to relatively harmless residues. They are therefore not likely to become long term pollutants.

Many insecticides also have relatively short lives. Some of these, such as the older organophosphorus insecticides like parathion, may be acutely toxic, and have caused many deaths to man and to wild creatures, but this damage has been from misuse and carelessness.

The group of insecticides generally thought of as pollutants are the organochlorines, including DDT, dieldrin, aldrin and endosulfan. As acute poisons, there are nothing like so dangerous as parathion; their danger lies in their persistence. They are also relatively insoluble in water, but readily soluble in fat. This means that they may be absorbed and concentrated in the body fat of animals.

As is well known, traces of DDT and its breakdown products have been found as contaminants in all parts of the world. In Britain everyone has some two parts per million of these substances in his fat. This he has obtained by concentrating the insecticide occurring in his food, generally at levels of about a hundredth those found in the fat. This process of concentration is remarkably efficient, but only proceeds to a limited extent. Therefore our own body levels have not changed much for the last few years, and they are now tending slowly to fall as the DDT levels in our food fall also. In America, where contamination rates are higher, body levels are four or five times those found in Britain. Were DDT completely eliminated from our food, we would slowly get rid of the substance from our bodies, reaching somewhere approaching zero within a year.

I think it is most unlikely that the DDT in our bodies does us the slightest harm. We know that individuals working in factories where insecticides are handled in bulk may have a hundred times as much, without showing any clinical symptoms. This finding has been confirmed by feeding different amounts of DDT to volunteers. We do know that high amounts, one ounce

in a single dose, smaller quantities taken regularly over a period, may cause sickness or death, but with our level of contamination there would seem to be a margin of safety of one in several hundred. Thus I do not think that we have any reason to be worried that the levels of DDT in the environment in Britain are directly harmful to man.

Nevertheless most ecologists are urging an immediate ban on DDT and other organochlorine insecticides in Britain, and their withdrawal from tropical countries as soon as safer, by which they mean less persistent, insecticides are available as replacements. The reason for this is that there are circumstances where very low levels may have serious ecological effects. This happens particularly in water, where fish and some invertebrates can concentrate these substances by a factor of as much as 10,000 times. This was noticeable when, in the summer of 1969, the Rhine was polluted with the organochlorine insecticide endosulfan. The levels in the water were apparently only in the region of one part in a hundred million, yet the fish concentrated this to lethal levels in their tissues. This they did because they breathed the water, passing enormous volumes through their mouths and over their gills, absorbing the oxygen *and* the endosulfan. Man could have drunk this water safely as every litre only contained a hundredth of a milligram, a hundred thousandth of a dangerous dose.

Notwithstanding the widespread contamination of the world by DDT and allied chemicals, I do not believe that they will inevitably do widespread and permanent ecological damage on a world-wide scale. We know that, over large areas in North America, they have done serious damage to wildlife, particularly to predatory birds which concentrate the contaminants in their prey. In Britain some ten years ago we saw this same process at work, and many feared that the damage was irreversible. However, by a typically British compromise solution of a 'voluntary ban' on the most dangerous uses of the particularly toxic chemicals, we have in fact reversed the situation and there is some recovery of the most seriously affected species. Incidentally this voluntary control has worked better than the more drastic legislation in other countries, where there has been less goodwill and co-operation between users and conservationists.

My reason for optimism regarding DDT and the other organochlorines is that I believe that we have acted in time. These chemicals are still being manufactured and used, but their use is beginning to tail off. Had their use increased exponentially, as it might have done had not naturalists and conservationists sounded the warning, great harm could have been done. But today the levels are likely to be contained before really widespread

damage is done. For instance, I do not think there is any evidence that organochlorine levels in the oceans will rise to those where phytoplankton, and so the whole economy of the seas, will be affected. These substances are longlived, but they do eventually break down, and I believe that we shall soon see their levels decrease and the instances of proven ecological damage disappear. However the whole story shows the need for vigilance, and that the naturalist, by seeing ecological upsets at an early stage, must occupy an important place in our early warning system.

Insecticides are deliberately introduced into our environment with the purpose of killing unwanted organisms. Other man-made substances, which can be equally dangerous, may also find their way there unintentionally. In recent years we have found another group of substances, the polychlor biphenyls (or PCBs) in the tissues of wild birds and even in human fat. These PCBs are synthesised by the chemical industry, and used in making plastics and other substances. Like the organochlorine insecticides, they are soluble in fat, and they have some insecticidal properties. They were first discovered in birds as their presence interfered with the analytical techniques used for insecticides. However, they were soon recognised for what they were. The levels were usually low, one or two parts per million, and toxicological experiments suggest that these should be harmless. On some occasions, as in the dead birds found around the Irish Sea in the autumn of 1969, much higher levels were found. The reason for concern is that we have no idea how these chemicals have found their way into the environment. The fact that, up to now, the amounts present may not usually be harmful is reassuring, but does not remove all causes for worry. Other substances may be synthesised and released unintentionally with drastic consequences. This puts a great burden of responsibility on the chemical industry. They must ensure that if substances which could be ecologically damaging are produced —and we now have some idea of the properties of potentially dangerous substances—then extra precautions will have to be taken. It is encouraging to learn that the Monsanto Chemical Company, the main producer (though not the user) of PCBs, is trying to obtain international agreement to cease using these substances. We may have avoided damage from PCB, but can we be sure that other and more dangerous chemicals will not be produced to appear unexpectedly in our environment? Here again an international monitoring system is needed, to be on the lookout for possible new pollutants.

Recently there has been much concern lest our environment should be damaged by pollution with mercury. Contamination has been found in fish sold for human food. The story here is rather different from that relating

to DDT or PCB. Mercury occurs naturally as an element, combined with other elements to form various salts or ores. Metallic mercury is fairly poisonous, but its compounds have a wide range of toxicity. Thus mercurous chloride or calomel was commonly used as a purgative, so it is not very toxic. Some of the organic chemicals containing mercury, particularly the methyl mercury substances, are very poisonous, and they are also fat-soluble, persistent, and can be accumulated by animals as can DDT. Organomercury compounds, including some containing methyl groups, have been used as fungicides, particularly as seed dressings for cereals. I do not think that these have done serious ecological damage, particularly as in recent years efforts have been made to substitute the least dangerous forms for general use. The great bulk of mercury is used in the woodpulp industry, and some 500 tons annually have been released into our oceans in recent years. In enclosed seas like the Baltic there has for some years been evidence of a build-up to toxic levels, and deaths have occurred in Japan in men eating fish caught near an effluent source. However, we have recently been surprised to find appreciable levels, in the region of one part per million of methyl mercury, in tuna fish caught in the open sea. So far the levels found in human food in Britain have been insufficient to cause damage to health, and the decision of the Minister of Agriculture not to withdraw the affected tuna fish from sale seems to me to be correct. It should be realised that one four ounce tin of the fish contained less than a tenth of a milligram of methyl mercury, in itself a quite innocuous amount, and although a part of this would have been retained in the body and accumulated together with other amounts if ingested, even daily consumption of this amount would not build up to a toxic level. However, this does not mean that the incident is not serious. It indicates that mercury is entering our food supplies, and may also affect other forms of life which may be more at risk. The particularly interesting point is that the mercury contamination was in this particularly toxic form. This has been produced, naturally, by bacterial action in the sea. This demonstrates the complexity of the situation. Man releases a not very dangerous pollutant in a not very toxic form, and then this is transformed into something very much more poisonous and this is concentrated to an appreciable level. We must act on this warning, and ensure that there is much more stringent control, on an international basis, of what is discharged into the sea. I believe this is something that has been learned from the appearance of all these persistent poisons. So far they have not done serious damage. With care, they need never have such effects, and hysterical statements implying that we are all in immediate danger of fatal mercury

poisoning are not only untrue, but may prevent industry and governments from taking the matter seriously. In all these cases I believe that we have been warned in time, and that we must take all possible steps to prevent worrying but harmless contaminations from growing into the dangerous pollutions which could result from uncontrolled industrial development and irresponsible dumpings of dangerous effluents.

One final form of possible pollution is an increase in levels of radiation throughout the world. We must all realise that man-made radiation arising from a nuclear war could render the globe uninhabitable. Stores of atomic weapons may serve as deterrents, but the risk is always that some madman will actually use the deterrent. This is obviously the greatest risk to mankind. There are, however, risks from the peaceful uses of nuclear power. So far all the authorities concerned have adopted the most stringent precautions, and spent, in proportion with other forms of pollution control, an astronomical sum. The amount of extra radiation from all nuclear power stations and nuclear wastes is at present less than one per cent of the natural background radiation which exists without man's contribution. However, we cannot guarantee that this situation will continue to exist. Man is exponentially increasing his demands for power, and at the same time he is exhausting all conventional energy sources such as the fossil fuels. There is bound to be a tremendous increase in nuclear power stations, in all countries of the world. Can we be sure that everyone will continue with the present expensive precautions against pollution by radiation? We then have the problem of radioactive waste. Even today it is becoming increasingly difficult to dispose safely of the existing amount of such waste; with a thousand-fold increase in the industry, the problem will be a thousand times as great. If I am asked what is the most serious pollutant likely to affect the world on a global scale, I think that, eventually, this is very likely to be radiation.

I have tried to give an objective picture of the risks of pollution to our world. I have indicated certain dangers, and the ways in which these can be avoided. I do not think that catastrophe is immediately imminent, and I think that, for a time, technology with international co-operation can ensure progress and a better life for many.

However, I have omitted the most important question of all—population. It seems inevitable that by the year 2000 the world population will have doubled. This will cause great difficulties and discomforts in some parts of the world; but it need not cause disaster. I believe that we can feed these numbers adequately, and that we need not be overwhelmed by their

pollution. I do not believe that industrial development to give all those in the poorest countries in Asia and Africa a standard of living equivalent to the middle-class American is possible, and I believe that those of us in the more fortunate countries may actually need to accept a serious cut in our material standards in contrast to the golden future foretold by politicians of all parties. I believe that we in Britain at least need not, and will not, suffer from increased levels of pollution. I think that mankind may have as long as thirty years to solve its population problem. If it does not, then the gloomy prognostications of the doomsday men will inevitably come true.

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Dr Kenneth Mellanby is well-known in many fields of applied science and of educational administration. Educated at Kings College, Cambridge, he first made a name in research at the London School of Hygiene and Tropical Medicine. In 1947 he became the first Principal of the new University College of Ibadan in Nigeria, and continued to hold that position until 1953. Later he was back in Great Britain in charge of the Department of Entomology at the Rothamsted Experimental Station. Since 1961 he has been Director of the Monks Wood Experimental Station, Huntingdon, and in 1970 became well-known to a wide public through his outspoken comments on television and radio in connexion with the work of European Conservation Year.

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