Agriculture and the Public Health

The Milroy Lectures, 1970

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Among the remarkable, almost prophetic, suggestions made by Dr Milroy for the guidance of lecturers honoured by the terms of his endowment, was his belief that the science of human pathology would be profitably advanced by a better knowledge of the diseases of domesticated animals, and, I might add, knowledge of the natural laws that govern disease in man and animals.

Animal and human health are closely interrelated because biology is indivisible. Regarding the diseases common to both, the zoönoses, of which about 140 have been listed, I am concerned only with those involving farm livestock. Apart from effects on man, these diseases exert a profound influence on the practice and standards of agriculture and animal husbandry.

The quality of agriculture in any country determines human nutritional standards, so the medical profession cannot ignore the basic biological processes that underlie such standards. It is a sobering thought that the principal cause of the rise in world population is probably medical technology. Two Frenchmen, Dumont and Rosier (1969), have expressed this forcibly. 'The phenomenon of underdevelopment lies essentially in the fantastic gulf between a runaway population growth and a stagnant economy. By sending our doctors and missionaries to these countries before our agronomists, we have enabled their children to survive epidemics but not to have enough food to live decent lives.'

THE ZOÖNOSES

With most major public health problems of the past under control, there is now an opportunity to deal with the animal diseases likely to affect man. Indeed, this is necessary because it is apparent that the spread of disease from animals to man is increasing, due to modern techniques in animal husbandry and in food processing.

Tuberculosis

The eradication of bovine tuberculosis in this country is the greatest public health achievement of the century, and a feat accomplished by our veterinary

colleagues. In those European and other countries where the disease has bee eradicated, human bone and lymph node infection are now things of th past; elsewhere, much still remains to be done. However, success must n give rise to a false sense of security because cattle, in their turn, can be in fected from open human tuberculosis, and the discovery, at routine testing of a reactor in an attested herd has led to the detection of lung infection in stockmen.

During the long and costly elimination of bovine tuberculosis in thi country some fascinating problems have arisen concerning infections wit non-specific acid fast bacilli. These have been of the kind seen from time t time in human infections of the urinary tract and, occasionally, of mesenteri lymph nodes at first sight regarded as tuberculous but not proven to be s after biological tests.

The true nature of non-specific reactions in cattle may not only be difficu to interpret in life, but even to demonstrate after slaughter; for exampl many years ago I had a cow of good milking strain from whom a calf was muc desired. Until then we had never had a reactor at any herd test; suddenly, a a routine test, this cow came up as a reactor and was confirmed on re-testing Because we were very anxious to have a calf from this cow, the Ministry o Agriculture permitted arrangements to isolate her on the farm until she calved Meanwhile, we used every possible diagnostic means to try to determine whe the infection lay. Everything was negative clinically and in all clinicopatho logical aids to diagnosis. In due course she produced a bull calf which ultim ately went to Kenya. There, some years later, I regret to say, he was kille and eaten by a leopard. As regards his dam, she was slaughtered after calvin and a post-mortem performed. There was nothing amiss except one steri fibrous nodule in the skin of the neck, which we had noticed during life— site in which such nodules may be found due to non-specific infection wit uncultivatable mycobacteria. A better understanding and classification o these microbes is a task confronting bacteriologists at this moment.

Brucellosis

Brucellosis is much in the news because of the present campaign to eradica the disease from our national herds. It is often stated that the only caus microbe in this country is *Br. abortus*, but this is not so. Instances of melitens infections, now labelled *Br. abortus* type 9, occur here, and recently I w consulted about an outbreak in a dairy herd that had infected its owne This all arose because an immigrant navvy, employed on a large public wor contract, fouled some land to which cows had access. Such imported infectio are likely to become more frequent and serious because of the rapid increas

n human movement between the Continent and these islands. Another nstance of unwanted infections being introduced is provided by the seven ~ses of human *Br. melitensis* infection from eating contaminated Italian cheese (Galbraith *et al.*, 1969).

While *Br. suis* can be regarded as a USA infection, there has been one limited utbreak in pigs in the UK. How it arose was never discovered. *Br. suis* nfections, which mostly occur in Chicago slaughtermen, demonstrate the nvasive powers of brucellae through small skin abrasions, a frequent portal of ntry first observed by Morales Otero (1929), that has tended to be disegarded. The emphasis has been on orally acquired infections. Many of the ecent cases of brucellosis in those handling cattle have been in people who ave not even drunk unpasteurised milk.

The true incidence of human brucellosis in the UK is difficult to determine ecause the disease is not notifiable. A recent survey (to be published) was ade among veterinary surgeons in Northern Ireland, a region where cattleeeping standards are high. Out of 123 subjects examined, 100 had significant gglutination titres in their sera and 50 showed clinical evidence of infection.

The first move to do something positive about brucellosis in cattle was xactly sixty years ago. At that time, the Devon Farmers' Union (1910) urged he Government of the day to assist in the eradication of abortion and, also uberculosis; however, nothing was done. The eradication of brucellosis is an peration full of hazards because of the bizarre nature of the disease and the ersistence of the causal pathogens which, even in soil, can remain viable for s long as six months. In animals, the time is much longer, probably several ears, so brucellae can be excreted in milk or droppings quite unpredictably. his feature raises problems when protective vaccines like S19 and 45/20 are sed, because S19 contains attenuated living microbes. Brucellae are characrised by persistence; so where do they go after they have been injected? he only time you can be sure of where they are is when they are in the vaccine ottle or the syringe with which the calves are vaccinated. The vaccine can asily produce the disease in man, as is convincingly demonstrated when omeone has been accidentally injured by a syringe needle during a vaccinaion session.

The popular indicator for bovine brucellosis is a serum agglutination test. h the absence of overt disease it is still impossible to say what is a significant itre. The same considerations apply to human sera similarly examined; s much as 10 per cent of human sera shows a level of antibodies to *Br. abortus* uggesting active infections, yet these people have never suffered any illness. Within the past few years two new tests have been developed which distinguish etween recent infections and others (Kerr *et al.*, 1968).

The significance and trustworthiness of existing serological reactions have been questioned during the national eradication campaign now in progress. Some of the findings have been quite amazing; apparently healthy herds have come up with many positives, whereas other herds with few or no reactors have suddenly had clinical abortion due to frank disease. What could be serious, however, is that the existing government scheme, a voluntary one, permits farmers who blood test their herds voluntarily to sell reactors without disclosing that they have ever been tested. This matter was discussed recently in the House of Lords.

Vibrio Foetus Infection

As a venereal disease of cattle, the vibrio is another cause of abortion, which can also infect men and women, several instances of human abortion having been described (Vinzent *et al.*, 1950). Within the past few years strong measures have been taken to eliminate the infection from bulls that transmit it. Apart from the risks to man, this is very important because of the increasing use of artificial insemination in dairy herds. On three recent occasions bulls of my own have been used for the national artificial insemination service and I have seen for myself the great care to prevent spread of infection exercised by those conducting this service.

Mastitis

A rather different type of infection in dairy cattle, of human importance, is mastitis. The commonest cause of bovine mastitis is *Str. agalactiae* which, as far as is known, is not transmittable to man, but mastitis due to other streptococci has caused large outbreaks of human tonsillitis. This is now less common owing to treatment of mastitis with penicillin.

A much more serious form of mastitis is due to staphylococci similar to those in man. Many of the infections encountered are due to drug-fast strains, thus providing a new reservoir of these pathogens. I know at least one case of severe human infection acquired from an infected quarter in a cow when the causal microbe was completely resistant to all the commonly used antibiotics. The primary staphylococcal infection of cattle may be derived from human pimples and boils, or from staphylococci which are normal inhabitants of the udder skin but become pathogenic when a teat is injured.

Klebsiella aerogenes, responsible for a variety of diseases in animals, can also cause acute mastitis, and it is quite possible that this infection is derived from human sources.

Bacillary Infections

Until fairly recently it was thought that bacillary infections of farm livestock were due to pathogens specific to them, but it is now known that some infections, particularly of the salmonella groups, can affect man and animals indiscriminately. Coliforms are host-specific in man and in various animals.

Bovines of all ages suffer from bacillary infections, most commonly *S. typhimurium* and *S. dublin*. *S. poona* has also been identified in cattle, and an outbreak of human disease from this new source has occurred already (Hughes and Speller, 1969). It is interesting to note that Sir William Savage, the distinguished MOH, originally drew attention to the bovine reservoirs of infection from close study of outbreaks of human disease.

Acute bacillary disease of various kinds in calves reared intensively has a high mortality. Reliable data are difficult to obtain because, understandably, owners are reluctant to declare their losses. I know well-run farms where the mortality exceeds 10 per cent, and in one instance has reached 50 per cent. A curious feature of these intestinal infections is the commonly associated viral pneumonia, and this interrelationship of the double infections is hard to define. At our local hunt kennels literally dozens of dead calves are sent in. Many have had pneumonia, but I have yet to learn a means of distinguishing at post-mortem a purely terminal pneumonia from primary concomitant disease.

Most calves that survive acute salmonella infections, and probably adult bovines too, become carriers. Since nowadays calves from West-country markets are sent all over the country, and to Scotland, for rearing and finishing, it is easy to appreciate the dissemination of salmonellae that is going on, but the increased use of vaccines may limit this spread.

The rising incidence of salmonellae in bovines may be seen in Fig. 1 prepared from data provided by the Ministry of Agriculture.

Pigs, like other domestic livestock, can also become infected with salmonellae, and the type distribution corresponds with that seen in human infections. *S. cholerae suis* is the commonest and of special importance because of the increasing number of human cases, often fatal, with characteristic clinical features and septicaemia.

Salmonellae are also disseminated in slurry, an increasing by-product of modern farming difficult to dispose of effectively.

Although bovines, especially as calves, can suffer from coliform infections, it is pigs, particularly young ones, that are the most affected, often fatally. The varieties of escherchia involved are closely related to those infecting human infants. In piglets, scour from this cause provides a striking instance of phased pathology, a term I coined when working on the chemotherapy of

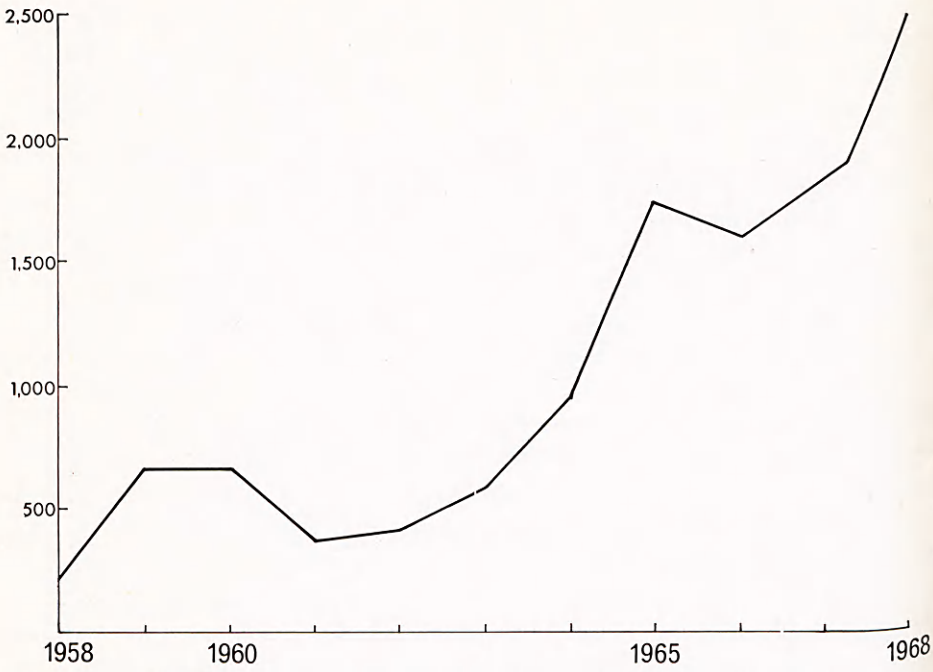

Fig. 1. Incidence of Salmonellae (all types) in bovines during the past 10 years.

human pneumococcal pneumonia. Maternal antibodies are effective for three weeks, which explains why piglet scour is uncommon in litters from sows allowed to acclimatise themselves in their pens before farrowing. During the next three weeks of life the young pigs develop their own protective antibodies.

The general metabolism of pigs closely resembles that of man. Certain methods of feeding have striking effects on their ball and socket joints, an effect commonly seen in pigs confined and fed in pens from weaning until slaughter at about 160 lb live weight. The appearance of the joints, with eroded cartilage, is very similar to the changes in human chronic arthritis of similar joints.

To prevent such changes in pigs required for breeding it is necessary, apart from careful feeding, to permit boars and sows free range during their growing period to have access to minerals and other trace elements about which we know so little. The exact nature of the ordinary feeding depends upon the conditions and circumstances on the farm. But, even under what could be regarded as generally favourable conditions for rearing breeding sows, care must be taken to prevent gilts being served by heavy boars, otherwise their hip

joints can be strained and chronic arthritis induced in what, by accepted standards, would seem to be completely healthy females. Once chronic arthritis develops in any sow the condition usually progresses and she is fit only for fattening and slaughter.

How often in human medicine we see instances of chronic arthritis in large joints which, often only after careful questioning, it is apparent have been subjected to a past sharp, but forgotten, injury. While not all human joints that are injured develop chronic arthritis it does seem as if there may be something inherent in the metabolism or make-up of certain people which provides a predisposing cause of chronic arthritis which can be triggered off by injury.

While not wishing to speculate too much, I have often wondered whether this predisposing cause can be due to some inherent nutritional defect: not because of lack of intake but possibly because of an inability to absorb or otherwise utilise some kinds of accessory food substances. After all, certain apparently normal people require extra iron, and the dose must be large to ensure adequate absorption.

Leptospirosis

Although Inado and Ido in 1915 discovered the cause of Weil's disease, in which rats are so often implicated, years were to elapse before it was realised how extensively the animal kingdom is permeated by spirochaetes, many of which are facultative pathogens. It is often said, probably with truth, that half the rats in this country are carriers of some variety of leptospira, but, somewhat surprisingly, the incidence of human infections with *L. icterohaemorrhagica* is declining. Not so long ago there were about 100 cases annually, but in 1967 there were only eight reported cases, and seven in 1968.

Hitherto, the most widespread spirochaetal disease of domestic animals has been *L. canicola* fever, with jaundice, in dogs. This is easily transmittable to man, causing an illness, without jaundice, somewhat resembling meningitis. Dogs may be infected with *L. icterohaemorrhagica* and this is now the commonest type of infection (J. A. Boycott, personal communication). I have myself seen how the incidence of 'yellows' in hounds is directly related to rat infestation of kennels. Get rid of rats and you get rid of 'yellows', likewise the infectious fluxes to which hounds are prone, particularly as puppies.

L. canicola has now become established in pigs, and several human infections from this source have been reported. *L. pomona* is generally regarded as the common infection of pigs, but no human infection from this source has been known to occur in the UK; in other countries it causes swineherd's disease.

The fairly recent recognition of leptospirosis in cattle presents a new biological problem, emphasised by the frequent positive tests on Continental bulls

proposed for importation to improve British beef production. Of 400 bovines recently tested, some 300 were infected with *L. icterohaemorrhagica*. In turn, British cattle are now being tested, but the extent to which they may be infected or act as carriers must remain unknown until more data are available.

Already it is clear that bovine leptospirosis is not merely a disease of veterinary importance. It is directly communicable from cows to man, and four instances of this have occurred (Mackey, 1968). The mechanism of infection is unknown. In the herd involved, no leptospira could be identified in the urine of 20 cows examined, 15 of which showed significant leptospirosis agglutinins to the hebdomadis group, generally regarded as primarily an infection of voles. Of special interest is the fact that a number of rodents trapped on the farm, which were suspected to be a reservoir of infection, were all found to have negative tests for leptospirosis.

The risk of spreading leptospirosis by bovine carriers is rapidly receiving world-wide recognition and many countries importing livestock from the UK now require them to pass an agglutination test against *L. icterohaemorrhagica*. Over the years, agglutinations have been carried out on my own stock, with completely negative results. Last year, however, a home bred heifer surprisingly reacted 1:20 to *L. icterohaemorrhagica*; a low titre, but there it was. To try to clarify the position, Colonel Hart at Millbank kindly retested her against various varieties of leptospira, some of which, as far as is known, are not found in the UK. The results of the investigation are shown in Table 1.

TABLE 1. Leptospiral Titres in Pedigree Heifer (re-test)

Icterohaemorrhagica (R.G.A.)	1:10	Erinacei-auritis (607)	1:10
Copenhageni (Coppard)	1:30	Erinacei-auritis (W.V. 14)	neg.
Bellum	1:10	Australis	1:30/1:100
Castellonis	1:10	Bratislava	1:100
Bulgarica	1:30/1:100	Pomona	1:10

The titres are low but positive, whereas all the other bovines with which this heifer was in contact were negative. It is an immunological mystery that human or animal sera can sometimes show reactions to infections the subjects have never suffered from or been in contact with.

Here it may be fitting to say something about rats. They always present a public health danger as carriers of leptospirae, salmonellae, trichinosis, viruses, and rat-bite fever. Fortunately, in the UK we are spared the risk of plague. Despite surveys, no one knows how many common rats there are here or how many there may be on farms. By a curious vagary of the law, farmers are the only members of the community exempt from the requirement to report

rats on their premises. They are, however, obliged to take steps to combat them if present in substantial numbers. One recent discovery is the inexplicable rise and fall in the rat population of different areas.

When anticoagulants of the dicoumerol type were first used as rat poisons it was thought that a safe and effective rat-killer had been found. But, as can happen with therapeutic agents in man, rat resistance has since developed to the new products. As early as 1960 it was found, on the borders of England and Wales, that rats were becoming resistant to anticoagulants; now, within ten years, this area of resistant rats covers over 700 square miles. Similar patches are appearing elsewhere, the latest in Kent, and others must be expected. The Ministry of Agriculture is well aware of the new problem, and in an effort to contain it, affected regions are being ringed with a three mile strip within which zinc phosphide is used as a rat poison.

Toxoplasmosis

Much about toxoplasmosis remains an enigma. Severe disease is very rare, although about half the adult population of England has antibodies indicating subclinical past infection. People in rural areas show this feature twice as commonly as urban dwellers, which might be expected, since the parasite has been isolated from most species of warm-blooded animals. Light cooking destroys the parasite in meat, but on the Continent raw meat eating has been shown to be a major cause of human infection. Herbivora are infected as frequently as carnivora and it is thought that, in the estimated 70 per cent of sheep infected, toxoplasmosis is a common cause of abortion. Robertson (1969) has produced highly suggestive evidence that the infection can cause human stillbirth and abortion. It is remarkable that we still do not know how a common parasite, identified half a century ago, spreads from host to host.

Poultry Diseases

The widespread incidence of viral infections in poultry flocks is a serious economic matter today. The viruses usually involved do not spread readily to man, despite close contact with them, but Newcastle disease can occasionally cause conjunctivitis. A disturbing discovery is that an avian strain of influenza virus and a human strain can be hybridised in the laboratory. This could result in the emergence of a strain with the extreme virulence of fowl pest but pathogenic for man.

Marek's disease, or fowl neurolymphomatosis, a malignant disease caused by a herpes type virus, is of interest to human medicine because it is possible that some malignant disease in man may be due to a related virus (e.g., Burkitt's lymphoma). Under certain circumstances the virus merely causes a

low-grade inflammatory reaction, possibly due to host reaction to the invasive pathogen.

The microbic diseases of poultry have hitherto been epizoötic in character, but this is changing, due to the spread to poultry of microbic pathogens causing human disease, thereby enlarging the reservoir of them. Little is yet known about the part that coliforms play, but the spread and effects of salmonellae in poultry in many respects resemble those in calves and pigs. Since ordinary methods of therapeutics and disease control are not easily applied to large poultry flocks, a more practicable and rewarding method is to use the general principles of preventive medicine, together with the localisation of any flock outbreaks.

The remote effects of these diseases must be kept in mind. What can happen was clearly demonstrated on Merseyside by the serious outbreak of human *S. virchow* infection from eating contaminated broilers. After recovery, some of the victims became chronic carriers of the infection (Semple *et al.*, 1968).

Metazoal Infections

The metazoal parasites of animals are of importance to man because of the risk of infection via the butcher's slab, but meat inspection in this country is so well done that few carcases with obvious cysts or other faults escape notice. Recent enquiries from butchers reveal that it is extremely rare for them to receive meat infected in any way. In most countries, meat inspection is required to be done by veterinary surgeons, which is a great drain on a profession with limited personnel, but in Great Britain meat inspection is competently done by Public Health Inspectors who receive special training for the work. In 1968 fifteen and a half million carcases were inspected, which indicates what these inspectors do. The results of these inspections can be seen in Table 2.

TABLE 2. Meat Inspection 1968

15·5 M carcases inspected		
Total rejections: 49,500		
Partial rejections (excluding T.B. and cysticercosis) 2·75 M		
Tuberculosis:	Pigs	110,000
	Bovines	950
Cysticercosis		4,500

It is fortunate that, except for fluke disease and rare cases of orf and louping ill, no common disease of sheep is transmittable to man. Due to the increasing size of roaming flocks and the wet summers of the past few years, *fasciola hepatica* has spread alarmingly in sheep. As a result, more contamination of

streams with infected snails (*Lymnoea truncatula*) has occurred and caused a sharp increase in the human incidence of fluke disease. This has always been due to the consumption of wild watercress infested with cercariae. Stringent precautions were always taken by commercial growers of watercress to prevent their water supplies becoming contaminated by sheep, and most large cress growers, who supply 95 per cent of the market, now get their water from artesian wells. Full chemical control of snails is usually impracticable, but flocks of ducks will often clear snails effectively, although this is not a method for universal application.

Scrapie

Scrapie, another disease mainly confined to sheep, shows how what might be regarded purely as an animal problem may lead to a better understanding of the pathology of certain obscure human diseases. This disease has been recognised for at least 200 years; its British name is derived from one of its symptoms, which is compulsive rubbing. In France, it is called *la tremblante*, which describes the hypersensitivity and trembling. There is no known way of altering or arresting its course. Despite the severity of the disease, the strictly bilateral lesions in the CNS are always microscopic and consist essentially of nerve cell degeneration, and vacuolation, clearly shown in the photomicrographs made by Mr I. H. Pattison, and published in a review of the disease in this Journal (Pattison, 1966). I am indebted to Mr Pattison for teaching me much of what I know about scrapie.

The important thing about scrapie is that it is due to what, for the present, is most appropriately called the scrapie agent obtainable from tissue extracts. This is a thermal and formalin-resistant substance that is self-replicating. It has been known for thirty years that infections of the agent will reproduce the disease, after an incubation of anything from four months to as long as four years. By some, this agent is regarded as a virus, but this is probably not so because no nucleic acid has been demonstrated in it.

It may well be that the scrapie agent is a third kind of pathogenic agent, forms of which might produce some chronic human CNS diseases, the causes of which remain unknown. At least three diseases must be regarded as very similar to scrapie, namely, kuru (in New Guinea), Jacob-Kreutzfeld disease (spongiform encephalopathy) in man, and an animal disease, encephalopathy of mink, so far only observed in the USA.

Some important experiments have been made by Palsson in Iceland. After inoculating sheep with brain material from human CNS diseases, including multiple sclerosis and encephalitis, some sheep developed scrapie. The interpretation of these results is difficult because of the apparent differences

between the morbid anatomy of two such diseases. However, the techniques developed in scrapie research and ideas based on the results of this may ultimately reveal the cause of human conditions.

Horses

Horses present features of much medical interest. Two or three hundred years ago there were more books published about their care and treatment than there were about similar human problems. Some books could have served as models for the study of man. Later, it was common for doctors to be consulted about equine injuries and ailments. It was a doctor named Collyns, practising in Dulverton in the early nineteenth century, who devised a successful tenotomy for cramps in horses, which in more modern times led to the idea of a similar operation to relieve human claudication.

One thing about horses, not widely known, is the remarkable dichotomy of their immune reactions. The haematogenous reaction is the most active of any animal and is exploited for the production of antitoxins, and, recently, an immunosuppressive agent for human use (antilymphocytic serum) has been prepared by immunising horses with human lymphocytes. In contrast, cutaneous cellular immunity is very meagre, so much so that unless great care is taken the smallest accidental injury almost always suppurates, mainly from necrophylic microbes. Possibly there would be a link between this surface sensitivity to injury and the absence of superficial adrenergic fibres in the skin, where vascular control and the characteristic sweating and breaking out is due, it seems, to direct biochemical reaction to adrenalin release. In bovines, quite nasty cuts and wounds rarely suppurate.

OCCUPATIONAL DISEASES

Of other human diseases directly related to the care of livestock, only one, farmer's lung, has yet been scheduled as an occupational disease. As early as 1600, Dr Richard Surflet wrote about human illness in the countryside, and later, in 1789, Dr William Falcner, FRS wrote a tract on the subject, using the terminology of the day. However, it was not until about thirty years ago that a distinguished Fellow of the Royal College of Physicians, Dr G. G. Morrice, first drew detailed attention to the respiratory diseases peculiar to rural districts of Britain. Farmer's lung, due to *micropolyspora faeni* was not then so common as it is nowadays, because hay was ricked and not baled; it is baled hay that so easily becomes dusty. The special nature of farmer's lung, and its allergenic basis, has recently been elucidated by Professor Pepys (1969).

Another respiratory disorder, much less common than formerly, is the

bloody bronchitis of the countryman. Due to its clinical features this disease has often been confused with tuberculosis, but the cause is a massive infection with *C. albicans*. Changes in hay-making methods probably explain its declining incidence. Other fungal diseases of the lung, often due to one of the varieties of aspergilli, are well recognised, and it is remarkable that such infections are not more common in view of the heavy contamination of farms with aspergilli, particularly *aspergillus niger*.

Few cases of 'Q' fever are positively diagnosed in people concerned with livestock, although *C. burnetii* are so common in and around the places where animals are kept, but even in livestock, 'Q' fever antibodies can be demonstrated in only 10 to 20 per cent of cattle, and 1 to 2 per cent of sheep. Pigs appear to be immune.

Many people in perfect health who handle animals show specific antibodies to *C. burnetii* without knowingly having suffered from the disease. More females than males are affected in this way, a difference probably explained by the close association of women with dairy work. Overt disease with pneumonia is rare, but commoner in men, who are more likely to handle infected material. Many cases of so-called influenza among farming folk have an unusually sharp onset, with respiratory symptoms, and those with a low fever tend to persist. A complement fixation test for 'Q' fever might settle the matter, but by the time a significant titre is obtained most patients have recovered.

The control and treatment of animal ringworm is a humbling experience, because when you try to do something about it, it is more than likely that you get infected yourself. Cattle ringworm is due to *M. discoides* or *M. mentagrophytes*, both of which fungi are highly contagious, with a predilection for human skin, in which they produce characteristic lesions. A closed herd will be free from ringworm for several years and then, disappointingly and for no obvious reason, it suddenly reappears. The fact that many treatments are recommended implies that none of them is much good. After the bare patches have cured themselves the problem of knowing how to stop fresh ones appearing remains.

Another human skin infection, formerly very common, is dairyman's itch, which is derived from sarcoptic infections of cattle or other livestock, and causes a lesion similar to scabies. Of the genera on mammals, numerous varieties of each species exist, but the differences between them are physiological rather than anatomical. Sarcoptic mange is now rarely seen in farm animals, due to the great improvement in the care of livestock, and this is also reflected in its declining incidence in man.

Cowpox, an unpleasant disease, needs little mention. It is now rare, mainly

because of machine milking. Since a Dorset farmer, Benjamin Jesty, first demonstrated, in 1774, its protective action against smallpox, the whole of mankind has continued to benefit from his discovery.

Anthrax is a human disease always derived from animal sources and the different forms of its clinical features are recognised and understood. In animals, however, natural immunity must vary very much because many infections are fulminating septicaemias; an animal may seem quite well in the evening but be dead next morning. With such a serious disease the strict rules laid down in the Anthrax Order (1933) are more than justified and, on occasions when these rules have been disregarded, the consequences have been disastrous.

It is understandable that much veterinary practice is based on human medicine but the therapeutic use in animals of medicinal agents devised for use in man is not entirely a one-way traffic. For instance, there would probably be no phenothiazine compounds or methypolysiloxane in human therapeutics but for initial veterinary experience of their potentialities. Furthermore, guidance from veterinary surgeons has made it possible for domestic pigs to play an important part in experimental medicine, and, recently, in organ transplantation. The larger domestic animals, whose size and economy reflect those of human beings more realistically than laboratory rats and mice, could be used a great deal more in the final screening of drugs intended for human use. Of interest may be the fact that the acceptability tests on the early injectable sulphonamides were made on some of my own sheep. Initial experimental therapeutic trials of certain types of drug should also be possible, thereby overcoming some of the difficulties, both ethical and practical, of bridging the gap between laboratory findings and initial application to humans.

CONTROL OF INFECTIONS

There are two main ways in which the diseases common to man and farm livestock can be controlled; preventive inoculation or vaccination to control overt infections, together with a reduction in the number of clinical cases by selective treatment, and raising the standard of general hygiene in animal husbandry, in combination with the application of what is already known about epidemiology in general.

By the very nature of things, animals live in contaminated surroundings. Provided they have an immunity to any pathogens that may infest their surroundings, all is fairly well until they meet an overwhelming infection. But under field conditions ordinary physical cleaning and disinfection will not eliminate gross contamination, and disinfection of the environment can be useful only when the parasite does not pass directly from host to host.

However, the better use of modern fogging techniques opens up fascinating possibilities of limiting aerial spread.

Certain viral and microbic diseases of livestock can now be contained by picloxydine preparations developed from those originally introduced to assist in controlling cross-infections in hospital wards (Couston and Campbell, 1967). Interest in better control of animal infections was further stimulated by a suggestion I made at the time of the foot and mouth outbreak in 1967, when certain picloxydine products were examined experimentally against the causal virus. Ultimately, by a slight adjustment in composition, it was found possible to produce a viricidal solution which should be valuable in helping to control future ravages of this serious disease. Recommendations about its use have already been made by the Ministry of Agriculture. Time will show how far it may be possible to apply these findings to limit the spread of human viral diseases.

The conditions under which certain foods are produced can cause or prevent animal diseases affecting man. Milk production provides the most striking example. A great deal of milk is still produced under conditions that would not be tolerated in a public lavatory. However, by persuasion, sweetened with government grants of various kinds, standards on all dairy farms are steadily improving. The increasing use of bails or parlours (Fig. 2) has greatly assisted clean milk production. The campaign to improve the conditions of milk

Fig. 2. Modern milking parlour (Courtesy of Gwilliam Ltd, Edington, Somerset).

production has been retarded by pasteurisation, a marketing process often relied upon to cover up production faults. It was introduced in the early years of this century by farmers some distance from London to ensure that milk was not sour by the time it ultimately arrived on metropolitan doorsteps. It also helped to lessen the incidence of human tuberculosis of bovine origin until the disease was eliminated at source. For many years I have been an opponent of over-reliance on pasteurisation, not because I doubt its ability to provide a short answer to infection problems, but because it has been regarded as an end in itself rather than simply as a means to an end, namely, to gain time to raise the standards of milk production. The idea of eating, or rather drinking, sterilised dirt is never pleasing.

It is claimed that pasteurisation has little effect on the composition of milk, and indeed, the only proven effect cited is a slight reduction in its ascorbic acid content, which can readily be replaced in the human diet by other means. However, the ascorbic acid content of other articles of food is falling, due to the increase in pre-packing and tinning.

There is another and more serious aspect of pasteurisation of milk. I would draw attention, even twenty-five years after the work was done, to the experiments made by Pottinger (1946). He studied the effect of pasteurised milk in the diet of many generations of cats examined under strictly controlled conditions. These cats steadily declined in their general health and physique, their reproductive power gradually faded and, finally, the surviving cats on pasteurised milk died out, whereas the controls were hale and hearty some years after the experiment started. Still, it is often said that animals used experimentally are not man, and man is an animal very resistant to unfavourable conditions; however, these experiments sound a warning, and their results certainly cast doubt on the desirability of regular use of dried or reconstituted milk for domestic purposes.

Developments in the modern production and preservation of foods are altering the whole character of the nation's diet. It might well be in the public interest that the Royal College of Physicians should investigate the long-term effects that modern food processing and preserving may have on the common welfare.

INCREASED FOOD DEMANDS

Apart from the overall improvement in animal care and husbandry still needed, agriculture generally must progress to meet the increasing demands for food, not only in the United Kingdom, but throughout the whole world. With a population density in the UK of 225 people per square kilometre, it is useful to recall Lord Woolton's dictum during Word War II that we should

try to grow our own protein in this country, and import our calories. At present we are producing 62 per cent of our protein requirements. Three quarters of our animal protein is also home produced, a proportion that should increase with still better husbandry. In contrast, only two-fifths of our vegetable protein from cereals is home grown, but in years to come new varieties of maize may augment this fraction. In other countries the remarkable new varieties of rice being developed should do much to increase local supplies of a grain that is the staple food of half the population of the world. Some of the corn-producing countries that have been able to send us their surplus now need it for their own use, and there are other countries besides the UK that require to import corn to supplement their increased needs, due to rising populations. The present glut of Canadian wheat and French butter are passing events due to special circumstances, mostly man-made.

One factor governing food production is the land available for growing it. It is estimated that there are 4,000 million acres of productive land in the world. This at the moment has to feed 3,000 million people, and a recent estimate puts that figure at about double by the end of the century. Of the increased population 75 per cent will be in the poorly developed and poorly nourished countries. The lamentable ground-nuts scheme of twenty years ago demonstrates the difficulty of finding new land fit for agriculture.

What were once large food-producing lands are already completely out of production, having become deserts as the result of improvident husbandry and over-grazing. In North Africa the Arab goat has done much to ruin what used to be the granary of the Roman Empire, while large areas of fertile land in the Middle West of the United States, believed to have limitless yields, have now become a dust bowl. Dust storms now sweep the land where only thirty years ago the soil had simply been mined for cash crops. Elsewhere similar things are happening. No less a man than General Smuts used to say about Africa that its problem was not a racial one but one of soil erosion. In the UK, ominous dust storms have already started in several counties, due to changes in the manner of arable farming including the removal of hedges and trees which acted as windbreaks.

God has promised that while the earth remaineth, seedtime and harvest shall not cease. Is it not up to us mere mortals to ponder on this when, for short-term gain, we flout natural laws and the agricultural experience of thousands of years? In days when we are exploring the moon it behoves us still to think about the earth.

In the UK each year 40,000 acres, or an area that in twenty years adds up to an area the size of Devonshire, are irretrievably lost to houses, factories, and roads. When one recalls that every thousand acres lost means the loss of

food for about 2,000 people, alternative means of producing food must be found. This has drawn attention to the potentialities of what is called 'marginal land', land which normally would not be highly valued for agricultural purposes. For geographical reasons our own marginal land is often difficult of access and difficult to work, while in Scotland, for instance, climatic conditions limit the extent to which it may be used.

Marginal land has for a long time provided many of the open spaces desired by town dwellers for exercise and recreation. As such land is reclaimed for food production its availability for recreational purposes declines at a time when the motor car makes it easier of access, which shows the necessity of reconciling agricultural needs with the recreational use of the countryside for an increasingly cramped, crowded, overfed, and under-exercised population. The Forestry Commission has already shown how this may be done, and the Access to the Countryside Act (1966) is timely. For more than a century 'urban lungs', about which I have written in the past (Thrower, 1964), have been a feature of most of our cities and towns; it is a reasonable supposition that positive health has benefited from these lungs.

INCREASED PRODUCTIVITY

One thing that can be done almost anywhere in the British Isles is to increase the yield per acre of our remaining land without, it is hoped, causing soil impoverishment. In the past ten years food production has increased by 44 per cent; but the law of diminishing returns has begun to operate in the past year or two. At present, however, a national crisis in agriculture is fast approaching due to other economic causes. Concerning increased productivity I might quote something written to his sons, in 1655, by Sir Richard Weston of Sutton, Surrey: 'You will find the Improvement by Husbandry (after you have once had experience of it) to be very pleasing to you and so exceeding profitable; that it will make you diligent: for no man of any Art or Science (except an Alchemist) ever pretended so much gain any other way.'

Among the various methods of increasing productivity, two are of great medical importance, namely the use of insecticides and the selective herbicides commonly called 'weed killers'. Insecticides are available to control more than 3,000 different species of insects that infest crop plants everywhere and cause untold damage, and herbicides can reduce many competitive weeds, which in this country alone cost farmers several million pounds sterling every season. Fungal disease of corn crops is also causing much concern.

It is unfortunate that much of the chemical research behind these new products has been rather fortuitous and has resulted in an array of active

compounds, many of which are toxic to man and animals unless carefully handled.

The classes of compounds used in agriculture fall into four groups:

1. Chlorinated hydrocarbons, typified by DDT (dichlorodiphenyl trichlorethane) and BHC (benzene hexachloride).
2. Organo-phosphates, typified by Parathion (O, O-diethyl O-p-nitrophenyl phosphorothioate).
3. The carbamates typified by Propham (isopropyl N-phenylcarbamate).
4. The 'hormone type' represented by 2:4-D (2:4 dichlorophenoxyacetic acid) and MCPA (4-chloro 2-methylphenoxyacetic acid).

The first three groups are used as insecticides and the last as weed killers which attack broad-leafed plants without damage to grass or cereals.

The toxic effects of these compounds on man and animals can be immediate or delayed, and many cases of acute and even fatal human poisoning have occurred after contact with them. Organo-phosphates are cholinesterase inhibitors, and carbamates are nucleotoxic, so poisoning by them can easily prove fatal, and the use of such compounds is controlled, or even prohibited, in some countries. In the UK since the Agricultural (Poisonous Substances) Regulations were made in 1952, only one fatality has occurred, and that was caused by a product now withdrawn from sale.

The chlorinated hydrocarbons have been in use for about twenty-five years, and DDT is the most widely distributed man-made chemical on earth. The good results from their use have been outstanding, particularly in underdeveloped countries. For most of this time these compounds have been regarded as not very toxic unless grossly misused. Because of uncertainties about the chronic toxicity and the possible inherent dangers to animals and plant life, their use has been banned in Sweden, Denmark, Canada, and New Zealand. However, some months ago, in a Report to H.M. Government, an Advisory Committee concluded that the use of DDT and related compounds was not the serious health hazard that had been feared, provided that reasonable care was taken. A recent survey in the UK revealed an average human tissue level of 3 ppm of DDT.

With existing disquiet about the ultimate effects on man of many of the various chemicals coming into agricultural use, it is important to note the opinion expressed in the most recent report of the Government Chemist (1968): 'From the standpoint of health it is reassuring to discover that so many of the items of human diet in Britain harbour only negligible amounts of these pesticide residues and that the total load, toxicologically speaking, is not excessive.' In the USA, however, the extensive use of pesticides has resulted

in accumulations in man, particularly in body fat, which, it has been remarked, by our standards makes Americans uneatable. However, it must be remembered that many of the compounds used do not degrade easily under normal biological or weathering conditions so that their ultimate fate remains obscure; indeed, the problem of the physician and of the farmer are much the same in that both use compounds of whose total effect they often have very little idea.

The compounds commonly called weed-killers are remarkably non-toxic provided they are handled and used sensibly. No one can blame farmers in this country for using compounds that have made modern farming systems possible, and that are, often, the only means of economic survival.

Chemical research is constantly finding new compounds, but it may take years to be sure that these exert no long-term ill effects. Since it is said to cost nearly £1,000,000 to devise and launch one new product, it is understandable that manufacturers are anxious to market them as quickly as possible. Drink and tobacco may claim their thousands, but unless we are continually watchful, modern synthetic chemistry may claim its tens of thousands.

Any consideration of chemical residues in places that may influence human or animal life should include mention of radioactive elements. National monitoring of the environment, and also of milk, is now done regularly to ensure that the contamination of soil or food by fall-out from the explosion of nuclear devices and other artificial sources does not go unrecorded. During this monitoring it has been discovered that the natural radioactivity of rocks and soil is greater than previously supposed. Aberdeenshire granite is much more radioactive than any soil contaminated by nuclear devices or power stations in the UK.

Very little radioactivity leaves nuclear power stations, but close control is exercised and the levels are not allowed to exceed limits set by the government ministries concerned. As an example, the authorisation for a typical nuclear power station confines the radioactivity of materials other than tritium in the liquid effluent discharged into estuary or sea to less than 200 curies per year. No ill effects can occur to either the marine life itself, or to those who consume it. When the power station is running normally the quantity sent out is, in fact, considerably less than the authorised limit. Large safety margins are allowed for in the calculations of the permitted quantities.

Because Strontium 90 does not occur in nature, tests for this isotope provide a reliable distinction between natural and man-made substances. A cause of some disquiet is that Strontium 90, which behaves biochemically as an alkaline earth, is deposited in bone. It was found in some hill sheep in which a slightly raised bone Strontium 90 was discovered that they were already

suffering from basic calcium deficiency due to their particular habitat, but farmers generally are so conscious of the importance of adequate soil calcium that even reactions of this kind are unlikely to occur frequently. In the sheep in question, the bone Strontium 90 was well below the accepted danger limit.

Experience has shown that because milk has a high calcium content and is simple to analyse, it provides a convenient indication of radioactive materials in food. It has been accepted as such by the Government. The levels of Strontium 90 throughout the UK remain satisfactorily minimal, even in milk from farms adjacent to nuclear power stations. There has been some anxiety about the ill effects such places might have on the surrounding countryside; happily these fears have no basis in fact.

ANIMAL HUSBANDRY

To say much about the cropping methods coming into use to meet demands for more food would be inappropriate here, but as regards animal husbandry, there is much of importance for all of us. It is evident that, as agricultural expansion progresses, morbidity and mortality among domestic livestock tend to increase, despite a better knowledge of disease control. When biological rules are disregarded, Nature, sooner or later, always sends in a bill. One possible solution is to try to raise the standards of animal husbandry by keeping stock in physiological surroundings and free from access to pathogens to a degree not previously thought possible; another is to increase the efficiency and rate of food conversion of all domestic animals. Increasingly large amounts of animal food are imported and the question arises of the desirability of importing food to be eaten by animals in this country, rather than importing the finished animal fed more cheaply in its country of origin. Home standards of livestock husbandry are already so good that it would probably be better to import foodstuffs to supplement home grown supplies.

Without greatly increasing costs much can be achieved by detailed improvements and applying biological principles to better effect. Here I might venture to cite a little personal experience. The average annual yield of dairy cattle in this country, twenty years ago, was about 550 gallons, which has steadily risen to the present 800 gallons. The latter might be regarded as a low figure when you see at shows or read in newspapers about cows that produce up to 2,000 gallons in a single lactation: cows that do this sort of thing are genetic freaks. Many years ago I gradually changed from some other breeds to the smaller Irish Dexters whose special qualities offered tempting scope for development. When I first kept them, they had an average yield of about 500 gallons per lactation, only just below the national average, but it has been possible to raise the herd average in my own establishment to well

over 700 gallons per lactation with a food conversion rate, on a weight for weight basis, 50 per cent better than that of the larger cows popular at the moment. This has been achieved by selective breeding to improve udder conformation, and by breeding cows of a somewhat different configuration from the accepted standard, which has greatly increased their overall efficiency. Needless to say, for a long time such new ideas met with opposition, but finally, at the 1969 Royal Show, I had the honour to lead as a champion a home-bred bull with all the new characteristic genetic potential I have tried to achieve.

Regarding the further improvement of arable farming, mechanical power is merely substituted for the horse power or man power previously used; there is no disregard of natural laws, but it may be salutary to note that 84 per cent of the world's cultivable land is still tilled by man and his animals.

FACTORY FARMING

The subject of better food conversion rates leads to factory farming, which is here to stay. It is a way to use land more economically and to improve food conversion rates in poultry, pigs, calves, and now lambs, so as to make them more plentiful for human food. In European countries and the USA, the new techniques enable the protein requirements of increasing populations to be adequately met. Elsewhere in the world, protein shortage steadily increases and will increase as long as population control and modern farming methods are ignored.

In farming, when dealing with stock animals, there can be kindness and sympathy, but sentiment and emotion must be regulated. Every farmer knows that badly treated livestock do not do well, yet some recent events, widely reported, could make one imagine that only people in towns know anything about the care of livestock. Indeed, many really important matters affecting nature conservancy, about which countrymen are the most fitted to judge, have become controversial simply through the misguided efforts of urban do-gooders. It is a pity that more of the public zeal and money for animal welfare is not devoted to the care and circumstances of many of our children. Some people judge animal reactions by human reactions but animals cannot be dressed in human clothes, and to try and do so is misleading; for example, recently, during lambing, two ewes got on their backs but were rescued. While they were on their backs, foxes had eaten away their udders and part of their belly flesh. Immediately these ewes had been turned up, they rushed around looking for their lambs, quite oblivious of what, one imagines, must have been intense physical suffering.

It is quite evident that livestock in intensive units, as conducted at present,

are more prone to disease than those reared in conventional surroundings. In fact, we are seeing in animals the sort of things known to happen to human beings in crowded conditions. But crowded conditions need not necessarily be slum conditions.

Two main groups of diseases affect intensive husbandry. Firstly, there are the usual epizoötics common in livestock and almost entirely confined to animals, such as bovine virus pneumonia and the avian leucoses. Secondly, there are the infectious fluxes, often due to microbes pathogenic to man. It is this group of diseases that is so disquieting, as new reservoirs of potential human microbic pathogens are being established. Whether certain viral infections can behave similarly remains to be seen.

It is in intensive units that great use has been made of antibiotics and kindred drugs, not only in attempts to provide cover against infections, but also as additives to foodstuffs. The growth rate of young stock may be enhanced by food additives such as penicillin, tetracyclines, and certain nitrofurans, and these have been increasingly used for over fifteen years. Such drugs have also often been used therapeutically without adequate veterinary supervision and some dealers have actually included a packet of drugs when delivering stock to customers. All this fills many with dismay.

In 1960 a special committee was set up to review the possible consequences of antibiotic feeding. This committee considered that the then current practices and legislation about the use of additives were satisfactory and that the economic benefits outweighed what were regarded as theoretical hazards. Had a couple of dog and stick farmers been members of the committee I think its opinion might have been different. The findings of this committee seemed to be in direct conflict with all that has been revealed about drug resistance in the past thirty years; indeed, five years before the committee reported came the first warnings about the phenomenon of transferable drug resistance. This resistance in microbes can be started by contact many generations back, and now we know it can affect all the common pathogens. Under farmyard conditions, where the number and varieties of microbes are high, the effects of transferable resistance are obvious. Dr E. S. Anderson (1968) has suggested that transferable drug resistance may well have been assisted by attempts to provide antibiotic 'cover' in herds, a practice that has been widespread.

Mercifully, the red light was finally seen in 1968 and the Swan Committee was appointed to review the situation. Its recommendations last November to restrict or prohibit the indiscriminate use of antibiotics in husbandry have been widely reported, and the likely form of future legislation is well known. Despite what has already been said publicly about the economic effects of these recommendations, experience reveals that good stockmanship can

produce results just as good as those claimed for, but often not achieved by, antibiotic food additives and 'cover'.

The current review of chloramphenicol, widely used in animals, is important. This drug can cause transferable resistance in almost any of the enterobacteria, which could nullify its efficacy in human typhoid. Drug fast strains of *S. typhi* have already been reported from several countries, in some of which chloramphenicol is freely on sale (Agareval, 1962; Murte *et al.*, 1962; Njoku-Obi, 1965). In France there have been instances of drug resistance in *S. paratyphi-B.* isolated from cases of enteric fever (Chabbert, 1967).

The possibility of antibiotic residues contaminating human food is often feared, and the effects of consumption could well be the unwanted ones recognised in some individuals after antibiotic medication.

From the purely public health aspects, a striking recommendation of the Swan Committee is that in the future, when an animal source is suspected of causing human infections, there should be a concerted medical-veterinary attack on the problem. At present, the powers of Medical Officers of Health and Ministry Veterinary Officers are very limited on such occasions. In my own experience as Chairman of a Public Health Authority, I have seen how the public health has suffered in the past due to lack of interdepartmental liaison and executive powers.

The recent antibiotic episode gives a valuable indication of the possible place in physiology of trace elements as growth factors alternative to those previously used. Their effect can readily be observed in animals, and so provide guidance to a better understanding of the part played by these elements in human economy.

In recent years there has been evidence that elements such as arsenic and copper can exert a beneficial growth-promoting effect. Copper is particularly valuable for pigs, and probably other animals too, which, under certain conditions of husbandry, readily suffer from deficiency anaemia. It was accidentally discovered not long ago that in human medicine the haematinic effect of iron was enhanced by a trace of copper, and the following facts illustrate the beneficial effects of copper on animal welfare.

For well over a century it has been an undisputed fact that a few defined square miles at the foot of the Quantocks in Somerset is an area to which ailing stock could be sent, and where they would rapidly recover. It was also known that cattle reared in this same area invariably did well. When I moved into the area many years ago, I heard about this and sought an explanation. In the middle of the region is one of the ancient West Country copper mines, and in due course I found a vein of ore running through my own land. Not long after this it was discovered that obvious benefits followed the addition of a

trace of copper to pig food, a now accepted practice, particularly for pigs unable to benefit from minerals obtained by free range.

SLURRY

Apart from their direct influence on human health the new units and modern farming practices have added to the increasing public health problem of slurry disposal, particularly if this waste contains salmonellae or other pathogens and ova.

Slurry is essentially a semi-liquid water emulsion of animal droppings, mainly from cattle and pigs, together with rotten organic material such as bedding straw. Varying quantities of slurry have always existed on any farm carrying livestock and its effective disposal in the past never gave trouble. It was scooped up and tipped on to the dung heap, which absorbed it, and the heap was periodically spread on the land. Also, there were no concreted yards, and much slurry would soak into the ground. But in recent years a number of things, generally regarded as farm improvements, have happened. Concrete has replaced gravel, or bare earth, so that slurry now drains off hard surfaces and probably reaches a nearby watercourse; and more plentiful water supplies permit the hosing down of yards. It is somewhat paradoxical that hosing down in and around dairies or yards, a practice encouraged in the interests of public health, has produced the serious problem of contaminated waste water.

Various infections of domestic animals and birds are spread by means of their excreta, and liquid farm waste of any kind, with its high content of microbes and organic solids, is therefore very difficult to purify. An average sample of slurry contains as much as 50 per cent of organic solids. The organic material in the concentrated daily slurry from a large pig farm with 400 head of stock is equivalent to that from a town of 10,000 inhabitants, so if farm waste were to be diverted into a public sewer, local authorities might have to enlarge their sewerage treatment plants to cope with the additional load. Thousands of farms with a slurry problem are nowhere near any sewer into which to drain, so the obvious solution is to try to return slurry to the land. To spread quantities of watery slop on certain kinds of land is always difficult and in the winter often impossible, and once again watercourses become contaminated with consequences that can be imagined.

This demonstrates the need for the domestic treatment of slurry on site before it is permitted to drain away on to land or into streams. Any form of treatment on site is very costly, and at present the capital and running costs to any farm with a slurry problem amounts to something like £3 per 1,000 gallons.

FERTILITY FARMING AND HEALTH FOODS

Of current interest are the special merits of fertility farming and the alleged greater nutritional qualities of foods produced by the system. Special food shops are opening in most towns and it is understandable that patients talk about them. It must be clearly understood that the preservation of soil fertility has always been the guiding principle of British farming. An important factor in successful corn or grass growing is the maintenance of the soil structure, which is achieved by ploughing in cellulose of many kinds. The yields of corn or grass grown in this fashion remain surprisingly constant. To obtain higher yields more plant foods must be made available in the soil. This is simply a matter of arithmetic. Any well-run dairy farm exports in the milk about 1 cwt of mixed minerals per acre every year, and this has to be replaced. Heavy corn crops will also denude land. Although the Romans knew nothing about soil chemistry, they discovered that regular liming helped to maintain yields. With modern knowledge of chemistry it is agreed that selected extra minerals are even more effective, always provided that the balance of the soil structure is preserved.

Figure 3 shows the yields per acre of wheat in this country at ten-year intervals since 1885. The sudden increase in yields about 1946 and since is mainly due to the wider use of modern fertilisers. In contradistinction to these national yields, those from purely organic farming are rather pitiful.

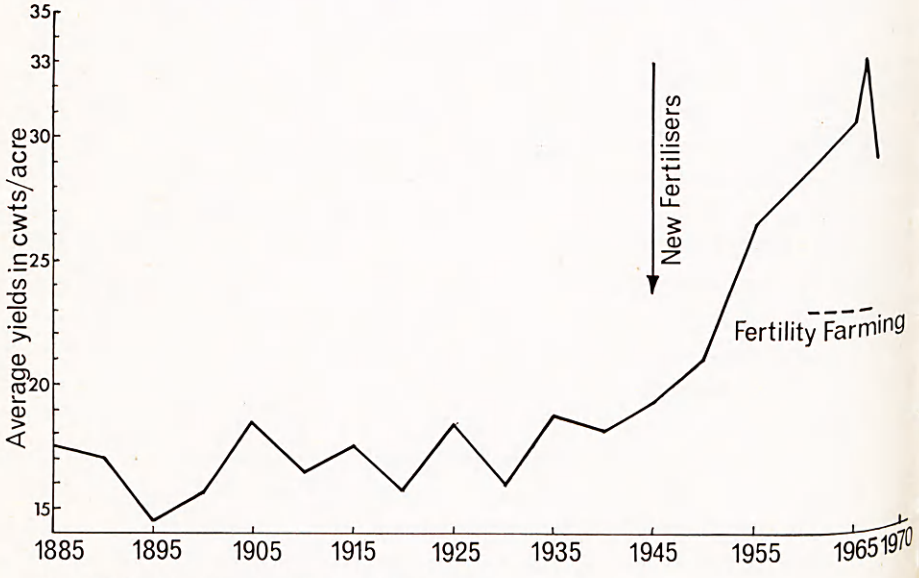

Fig. 3. Ninety years progress in wheat yields.

At one experimental farm the wheat yield is only 23 cwt per acre, and other corn crops are similar. There are categorical statements that in the long term 'organic' farming has advantages to human health, but no evidence in support of these ideas has, as far as I know, ever been adduced.

We must face up to the fact that the British public has very little interest in food values. In a recent survey only 6 per cent of people questioned knew what good nutrition meant. What is more disturbing is that in the same survey only 2 per cent said they learnt anything about this from their doctors, although 26 per cent had received advice about diet. Just what should constitute the national diet is, in the end, a medical responsibility, and if it is avoided, amateurs and faddists will take it over and attempt to guide the public. Inevitably, food production must come under increasing biological control, and we have a duty as doctors to ensure that this is done in such ways that the health of the public benefits to the utmost.

NEW PROTEINS

I have already indicated some of the new methods of husbandry by which it may be possible to increase supplies of natural protein so that we are not so dependent on traditional supplies. Is it possible to find new sources of protein from what are called non-conventional sources? Already there is evidence that protein may be produced from methane by methane oxidising bacteria or by yeasts grown on a waxy gas oil. Experiments on these lines in pilot plants have already been conducted for some years by the large oil companies, and proteins have been produced on a semi-commercial scale by biosynthesis. Initially, it is intended to study the use of such protein in animal feeding stuffs, rather than as a direct human food. Another untapped source of protein is the sea, and plankton as an animal food justifies further investigation. Fish farms, too, are already being started.

In time it may be necessary to educate public taste to new forms of food. We know already that the public can be educated in this way; for instance, tasteless broiler chickens are accepted as an economical alternative to the tasty but increasingly expensive roast beef of old England.

While we must not fall into the error of believing that modern technology and legislation can solve all the riddles of life, we already possess sufficient knowledge to solve many of the problems now confronting us in agriculture. It must be ensured that such knowledge is properly applied and that loose thinking or commercial carelessness do not permit some of the situations described to get out of control.

No form of biological development should be allowed to become isolated, because there is a danger that medicine or agriculture may come to be

regarded as a collection of technical achievements. To permit this lose of the interrelationship of human needs and problems, something possi the mind of the Apostle Paul when he stressed the dependence of the parts the body upon each other and surroundings.

The relationship between positive health and preventive medicine in a its aspects is as important today as ever. The concept was first propounde by Xenophon over 2,000 years ago in the words, 'As there are persons wh mend torn garments, so there are physicians to heal the sick; but your dut is far nobler and one befitting a great man—viz. to keep the people in healt (Xenophon, *Cyropaedia*, i, 6).

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