CEYLON ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE

PART II

PROCEEDINGS

OF THE

TWENTYTHIRD ANNUAL SESSION

19th to 22nd December 1967

COLOMBO 1968

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CONTENTS—PART II

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The Ceylon Association for the Advancement of Science

19th December, 1967

Opening Address

by

PROFESSOR G. P. MALALASEKERA
CHAIRMAN, NATIONAL COUNCIL OF HIGHER EDUCATION

I am most profoundly grateful to you for the honour you have done me, a mere layman, in allowing me to enter your magic circle and to share your confidences.

It is not for me to catalogue the benefits that have accrued to mankind by the improvements, discoveries and inventions brought about by advances in scientific knowledge. The changes that have occurred in the lives of men and women during the last one hundred years have been greater and more rapid than during any other period in human history and these changes have been almost entirely due to the work of scientists and technologists all over the world.

Science has now become part of our daily routine. Not only has it influenced and transformed life in its material aspects, it has also provided us with large treasures for our spiritual life. Man has arrived at a better understanding of himself and his place in the universe to an extent and depth inconceivable before. We have already begun to penetrate into the outer space beyond us and soon, perhaps, we shall be travelling to planets which had been considered completely inaccessible.

Sometimes Science has been pictured a man's struggle with nature to discover her secrets. Nature, so to speak, has been considered the scientists' adversary, reluctant to part with her mysteries. In our own philosophy, the philosophy of both Buddhism and Hinduism, the ideal has been for Nature and Science to work in happy partnership.

Up till now the advances in scientific knowledge have been mainly in the realms of the physical and biological sciences. It is only recently that scientific methods have been applied in the study of man's mind. Psychology thus became the youngest science though it is concerned with man's oldest problems. We of the East, especially in this part of the world, have always realised the importance of understanding the working of the mind. In Buddhism, for example, mind is described as being the creator of all things, because it is in the mind that our concepts have their origin.

It is to be expected, therefore, that when scientific methods of inquiry and investigation are applied in the realms of the mind with as much seriousness as they have been in matters connected with the physical universe, the discoveries made will be of tremendous significance, probably greater in their value than the more easily understood facts of the purely physical world.

All human progress, if in any way measurable, must be measured in terms of man's power over his environment, including his fellow human beings. As man now looks from his tiny planet out into the immensity of space, with its whirling galaxies, he feels he is master of all on earth and dreams of settlement even in other worlds. But, he is also afraid. It is of himself he is afraid, for this is the age of human crisis. It is the age when man's powers have become so vast that in an instant of anger or prejudice or folly man can destroy himself and this entire planet.

The problems of our age are in great measure the risks and quandaries arising from our new-found powers and our inability to find the honesty and the courage, the insight and the wisdom needed to deal with them. To mention only one fact, man is now almost in full possession of the means to modify the hereditary nature of every plant and animal and microbe he wishes. This staggering power over the nature of evolution provokes another great crisis in human affairs, the crisis of values and goals. The problem will now be not so much how to change man's nature as to what kind of human being we should wish to have. The control of human behaviour by artificial means has become a frightening possibility with babies bottled in different kinds of solutions that would control their mental growth. Hearts are being transplanted.

What will the psychological consequences be of a population with no personal ties either to the older or to the younger generation? Can we look forward to a brotherhood of man when there are no more parents, brothers or sisters or children but only isolated people? Only prolonged and profound attention to these problems by many of the wisest men of our time may achieve a wise and sober solution of the crises evoked by scientific discoveries and their applications. If civilization is to survive every citizen must learn what science truly is and what risks and quandaries, as well as what significant gifts, are engendered by the powers that grow out of scientific discovery. For the scientific society to be democratic and to remain democratic, the people themselves must understand the nature of the scientific forces and the problems that dominate their lives.

While on this subject of the need for communication between those engaged in scientific research and the common citizen, may I ask your indulgence to refer to something nearer home and something more particularly concerned with your own Association.

We are all aware of the tremendous improvements we in Ceylon have achieved in the field of public health. Almost entirely as a consequence of this improvement the death rate in Ceylon has dropped from 24 per thousand in the years preceding the second world war to 8 per thousand today. A few weeks earlier the President of the Institute of Engineers informed us that in the years after 1948 this country has built reservoirs with a capacity of millions of cu. ft. It has been observed by a team of specialists in railway transport last year that the Ceylon Government Railway with all its old equipment and curious narrow-gauge tracks runs fairly efficiently so far as the technical aspects are concerned. At the rice research station at Batalagoda, plant breeders have successfully hybridised a rice plant with a potential yield exceeding 100 bushels per acre. In all these our scientists and technologists deserve the praise and the encomium of the community.

Despite all these achievements we still remain desperately poor. The yield per acre of rice is barely 40 bushels taking the average for the country as a whole. The massive investment and the technological skill that formed the Senanayake Samudra in Amparai remains very poorly rewarded. The Ceylon Government Railway runs at a colossal yearly loss. The birth rate in the country remains as high as ever, except for a very faint shade of a drop during the last two years.

If we take these successes and failures together, I, as a layman, would diagnose the following weakness in the application of science and technology to the lives of the many thousands of poor and unsophisticated villagers in this country. The knowledge and the skill of the scientist and the technologist have failed to reach the point where it can be useful to increase the productivity of our labour. It is at times, though less frequently now than earlier, stated that this failure to pull into productive streams the energies of technological advancement is due to some innate and indelible characteristic in persons of certain pigments or physiological formations. But, most sensible people have reason now to believe that this is all *tosh*. To the best of my understanding, the failure in our society is due to sociological factors that constitute a barrier between the scientist and the technologist on the one side and the common man on the other, whether he be householder, peasant, fisherman or otherwise. In fact, I would go further and say that this wall extends further and stands between the intellectual and his community.

This curtain between the scientist/technologist and the common people, therefore, I regard as a specific instance of the common sociological pathology of our society. We were a divided house long before the advent of the Europeans. The Europeans introduced further divisive forces among us. Those who came to possess the scientific and technological skill eventually became a class apart, with behaviour patterns which set them apart from the rest of society. Their magical knowledge of English, their European clothes, their manners at table, their ideals in the arts and their spiritual Mecca in Western Europe, were characteristics which differentiated them from the Ceylonese community at large. At the beginning of this century a few seers like Ananda Coomaraswamy gave us some warning of the malignant growth, but we proceeded regardless. In consequence, we have scientific and technological achievements of great promise unused for the welfare of the good of the community because we have failed in effective communication with the common man.

I think this is a challenge which scientists and technologists must face fairly and squarely in much the same manner as they would a problem in nuclear physics, chemical engineering or molecular biology. I am afraid the problems are very complex since there is no laboratory in which the temperature and the pressure can be kept normal. Society at large becomes your laboratory and the only guinea pigs are human beings. And it is here that the social scientist has a vital function to perform. It is the sociologist and the economist who can diagnose the diseased cells, the malformed limbs, the decayed organs and the impoverished physique. I must here stress that the social scientists in our country

have not seriously addressed themselves to this task and this again perhaps flows from the same lack of sympathy between the scientist and the community at large to which I have already referred.

Estranged as he is from the local community and lured by the ample facilities for research and rich rewards for success, the scientist emigrates to latitudes further north and longitudes further west. I do not for a moment deny the greater productivity of the mind in an atmosphere bustling with intellectual activity, nor do I consider with levity the disparities in financial rewards to talent here and abroad. But, you will agree that I cannot but with greater concern view the demand here in Ceylon for competent scientists and technologists. Given the best will, it is unlikely that we here in Ceylon could provide the same facilities in terms of equipment and libraries as the better universities and research institutions of the west provide. But, I am sure that the scientist, working here under circumstances more trying than in the affluent west, could compensate for the loss of these advantages by his dedication to his immediate neighbours and to his own community at large.

As for the complaint that the atmosphere for research in our universities and similar institutions leaves much to be desired, I personally think the argument is specious. An atmosphere of research and intellectual activity is not merely some fair wind that blows from the west. It is as much the air that the scientist inhales as that which he exhales. To put it in another way, an atmosphere of research is not something that it is beyond the control of scientists to create. We, as a community, cannot afford to go on borrowing indefinitely. At some stage we must ourselves contribute to the world of intellectual excellence. We have done this already but only in some small measure, but our contribution must be much more substantial and take the form of gains of commanding size in the struggle with ignorance. When we think of scientific achievements, we should also bear in mind that the sum total of scientific knowledge and technological progress is and will continue to be an international achievement to which every civilized country has already made and has the potential to make some positive contribution. In the modern age, neither the size of a country nor the number of its inhabitants is any criterion of the kind and scope of the contribution it could make. We are increasingly becoming partners of one, single world.

The case for the retention of the services of scientists and technologists in their homeland does not rest solely on sentimental idealism. As you know so well, our community takes over the greater part of the financial burden of educating boys and girls from the kindergarten through the university. Even where the parents of a student finance his education, that which a person takes out of society needs to be paid back for moral reasons whatever be the laws of property in that country. It would, therefore, be reasonable to expect that those whose acquisitions from their community are scientific and technological skills, need to repay to that society the obligations they piled up. I perfectly agree that this payment could take many forms but I want to suggest that there is none so estimable as the application of one's knowledge and skill to solve the problems which hold the community in the grip of poverty, both material and otherwise.

While on this subject, may I make one more point. Intellectual excellence does not prosper where a person is under house-arrest. It would be far more desirable that a man be allowed to work as he will, at some institution where he wishes to work, rather than hold his talent in constraint by forcing him to work at an institution in his own country. Many tasks which on completion have been of great benefit to mankind are unlikely to have been embarked on but for some degree of idealism and dedication to a cause which is not totally rational, as the term is commonly understood.

In order to perform their functions satisfactorily, scientists and men of letters require the active support of the State. The Prime Minister recently announced to the Institute of Engineers that legislation to establish a Science Research Council is now being scrutinised by the Cabinet. This action would satisfy a long felt need in this country and form the first step in the formulation of a national consciousness of the importance of scientific research so that solutions may be found to the many problems that now beset this nation.

I have the greatest pleasure in declaring this Conference open and in wishing your deliberations every success.

General President's Address

19th December, 1967

THE PREVENTION OF CHRONIC DISEASES

by

G. H. Cooray

Prof. Malalasekera, Sir Max, Your Excellencies, Honoured Guests, Ladies and Gentlemen.

This is the first opportunity I have had, since my election to the post of president of this Association last year, to thank the members for the honour they have done me and the profession to which I belong. I am deeply conscious of this honour, but when I think of the distinction and attainments of my predecessors in this high office, my pride at joining their company is mixed with a very genuine and well justified humility. I must at the same time confess to you that I am at this moment experiencing feelings of apprehension and even of alarm at the prospect of facing this situation when I am called upon to perform one of the most important duties as your president. This I think is a reaction of most normal people towards duties of this type. However on this particular occasion these feelings are considerably attenuated, and I will admit that I was looking forward to this event, because it gives me the delightful privilege to speak in the distinguished presence of our Chief Guest, Sir Max Rosenheim, who not only is the president of that ancient institution, the Royal College of Physicians of London, but who has also been a close personal friend of mine right from the time we joined the University College Hospital of London as medical students thirty seven years ago.

The subject I have chosen viz. the prevention of chronic diseases may have taken some of you by surprise for the claims of a pathologist to speak on prevention may be questioned in some quarters. Pathology, however, is the science of disease, i.e. the study of all aspects of disease by scientific methods and one important aspect in this study is causation. Bodily changes which produce disease do not occur without a cause, although the explanation for the causation of some phenomena has still to be found. If then the cause of a disease is known it is not a difficult matter to devise ways and means of its prevention. If we are still ignorant of the causation of some diseases it is the duty of medical research workers to search for such causes.

The concept of disease prevention was one of the brightest spots in the history of medicine which was introduced in the nineteenth century. However, from the very earliest times men showed a desire to prevent illness, to promote health and preserve life as long as possible.

Susruta the great Indian surgeon laid down elaborate rules for the prevention of infection after operation and his suggestion that the wound be sterilized by fumigation is one of the earliest known efforts at antiseptic surgery. He also used clean hands and boiled water in his labour rooms.

Preventive medicine was also practised by our Sinhalese kings. It is recorded in the Mahawansa that Pandukhabaya in the year 453 B.C. employed 500 scavengers for cleaning the streets of Anuradhapura, 200 for cleaning the sewers and drains, 150 to bear the dead and 150 as watchers in the cemetry. He passed laws to ensure the sanitation of the city and law breakers were punished appropriately. The relationship between malarial types of fever and mosquitoes was known to the Sinhalese physicians about the 5th century A.D. and no less a person than Sir Ronald Ross has stated that "on 6th February 1905, Sir Henry Blake, Governor of Ceylon, called the attention of the Ceylon Branch of the Royal Asiatic Society to the fact that certain ancient Sinhalese writers had connected fever with mosquitoes". The practice of burning *madurutala* leaves to keep off mosquitoes in village areas probably stems from this knowledge. Public hygiene was inculcated in the minds of the Egyptians. The personal hygiene of the Greeks gave expression to the saying, "The fair mind in the fair body". In adopting Greek culture, the Romans not only accepted Greek ideas but also broadened them. Personal hygiene was an important feature in their life and the famous Roman baths were available to the humblest Roman.

The Greco-Roman concepts of hygiene declined with the downfall of the Roman Empire, but the loss, however was not complete. Enough of the ancient hygienic concepts remained for the medieval culture of Europe to build upon and the knowledge about disease acquired during the years made it possible to place the subject of disease prevention on a surer and stable foundation. Rapid advances in the prevention of disease were made after Jenner's discovery of vaccination against small pox. Howard too, had grasped the association of fever with over-

crowding in jails, while the possibility of preventing scurvy was pointed out by Captain Cook and Sir Gilbert Blane. Not till Bacteriology was introduced did preventive medicine become a complete science.

The problem of the prevention of bacterial diseases is not difficult as these usually result from a single cause. The growth potentialities of bacteria and the avenues available to them of entering the human body are well known to modern medical scientists. If, by chance, infection results from bacterial invasion ample remedies, such as antibiotics and other antibacterial drugs are available to effect a cure. The great achievements of public health and medical science have thus brought about a conquest of bacterial diseases and thus permitted people to live up to an age when chronic diseases become manifest.

Chronic diseases comprise all impairments or deviations from normal which have one or more of the following characteristics: are permanent, leave residual disability, are caused by non-reversible pathological alteration, require special training of the patient for rehabilitation, may be expected to require a long period of supervision, observation or care. Examples of these are—cardiovascular and renal disease, nervous and mental diseases, arthritis and allied diseases, permanent results of accidents, senility, tuberculosis, blindness, chronic diseases of the digestive system, cancer, diabetes and chronic results of communicable diseases. Advances in various fields of medical research made all over the world have made it possible to prolong the life of human beings with the result that they have become vulnerable to these diseases. Thus more and more people are now attacked by such diseases as heart disease, cancer and kidney disease. Further, medical advances are now enabling many with chronic diseases to survive the acute stages of these diseases. In this way chronic diseases have made a serious impact on the lives of millions of people and contributed to loss of life, disablement, family hardship and poverty and great economic loss to several countries.

Moreover, unlike in the case of infectious diseases which can be prevented by attacking the infectious agent or the vector or by improving the resistance of the host by immunisation, chronic diseases are not easily preventable because most chronic disorders are the result of multiple causes which include genetic factors, stress reactions, metabolic and endocrine disturbances and of the exposure of the individual to a wide variety of external agents such as bacteria, viruses, poisons, drugs, food, physical trauma and radioactive material. Not only should one be possessed of the knowledge of causation but one should also be familiar with the pathogenesis of such diseases because, in the case of some of these, the pathological changes responsible for the disorder are reversible at a certain stage of the evolution of these diseases.

A study of the morbidity figures in Ceylon show that accidents contribute to much illness while pneumonia, renal and heart disease are also responsible. Although it has been noticed that the mortality from tuberculosis has fallen after the introduction of anti-tuberculous drugs, the morbidity still remains high. Morbidity from mental disease and cancer is on the increase while malaria, typhoid fever and poliomyelitis appear to be under control. The almost total extinction of malaria is an epoch in the history of medicine in Ceylon.* Paralytic poliomyelitis has shown a dramatic decline all over the world as the result of the application of effective vaccines to large numbers of the population. Ceylon has not been unresponsive to the world war against this disease as our health authorities have been engaged during the past years in a programme of mass vaccination. Better water supplies, effective vaccination and adequate treatment, which have reduced the number of carriers have played some part in the control of typhoid fever which was a scourge in the early days.

As indicated, accidents are a potent cause of chronic invalidism. If one visits a surgical ward of any General Hospital it will be quite apparent that almost half the number of beds is occupied by accidental as well as by deliberate injuries. Quite a number of these patients become crippled as the result of the loss of limbs or other parts of their anatomy. If these could be prevented not only would hospital beds be made available for more urgent cases, but quite a lot of crippling disease which adds to the toll of chronic conditions could also be avoided.

Accidents could occur in the home, in highways and in industry but in Ceylon, highway and home accidents are the most frequent. In the case of road traffic accidents young men form the most vulnerable group in the population. It is estimated that for every death there are perhaps 30 to 40 persons injured—the injuries being so serious that the victims suffer from disabilities throughout the rest of their lives. This results not only in grave economic loss but also in increasing time spent in medical

* However, the success achieved by our antimalarial campaigners was short lived, for it is now apparent that malaria has manifested itself as minor epidemics in various parts of Ceylon. This indeed is a sad state of affairs because the early successes achieved in the control of malaria created a wave of optimism which made us feel that we shall be for ever free from the delayed effects of this crippling disease.

care and litigation. The prevention of such accidents requires a thoughtful analysis of their causation. Most traffic accidents have a multiplicity of causes. Although the road user is primarily held responsible for the accidents, the condition of the roads and vehicles often plays a part. While better designing of roads by engineers will prevent such accidents, the vehicles should be regularly tested for their road worthiness. Drivers should also be tested regularly. Unfortunately in Ceylon, once a certificate of competence is issued such a certificate is valid for the rest of the driver's life irrespective of the fact whether he possesses the capacity for vigilant attention and anticipation with the advance in years. Physical fatigue which exerts its effects through impairment of the neuromuscular co-ordination is another factor which reduces the efficiency of the driver. A large number of accidents could also be prevented by lowering of the speed of the vehicle.

Studies conducted in various parts of the world have shown a high correlation between accidents and consumption of alcohol by drivers and pedestrians. It has been estimated that, in the United Kingdom some 500 deaths and 2000 to 3000 serious injuries annually could be avoided if drivers and pedestrians kept off the roads after drinking. A W.H.O. expert committee has reported that "the inference cannot be avoided that at a blood alcohol concentration of about 50 mg per 100 ml. a statistically significant impairment of performance is observed in more than half of the cases examined" (1954). Other causes of reducing the efficiency of drivers which result in traffic accidents are epilepsy, coronary insufficiency, hypoglycaemic attacks in diabetics, deafness and the use of narcotics, hypnotics and tranquillizers.

Having discussed some of the factors that cause road accidents, it is appropriate to outline some methods whereby they could be prevented. Although public health authorities have, in many parts of the world, dealt effectively with the prevention of communicable disease, little attention has been given to the prevention of road accidents which result in chronic disability. Public health administrators should co-ordinate the activities of all those bodies that are concerned with improving the safety of the roads and the conduct of road users. More Zebra Crossings should be provided. Road designing should be improved. Narrow winding roads that were constructed before the development of motor traffic should be re-fashioned to satisfy modern needs. Dual traffic ways as well as separate lanes for pedestrians and cyclists should be constructed and moderate speed limits should be enforced. The money spent on such improvements is sure to pay ample dividends in not only reducing the mortality from such accidents but also in reducing the chronic ill health of victims who survive. Such measures will effect a considerable saving in the health services, budget and more man hours will be spared to the community. Vehicles too should be designed in such a manner as to make driving easier with minimum fatigue and maximum speed. Above all the regular maintenance of vehicles should be ensured. Road users should be educated and the motor drivers should be trained and a certificate of competence should be issued to only those who pass a rigorous test. Such certificates should be refused to those drivers with disabilities mentioned above and a periodic medical check up should be carried out. As far as alcohol consumption is concerned, legislation to prohibit drivers with alcohol levels exceeding 50 mg/100 ml. driving vehicles should be imposed.

It is scarcely necessary to mention that accidents which result in compound fractures of limb bones should be medically attended with the least possible delay. Such delay inevitably leads to infection and osteomylitis which may ultimately have to be treated by amputation of a limb—thus resulting in chronic disability.

Accidents in the home occur both in the young as well as in the old. In old people vision and hearing acuity decline, reflexes become sluggish, muscles weaken and the bones become brittle. Such people develop fractures of the neck of the femur after the slightest fall and become chronic invalids. To prevent such accidents the housewife or the attendant looking after such people should accept more responsibility and poorly lighted rooms, loose rugs and slippery floors should be avoided. In the case of the young, burns caused by kerosene oil bottle lamps—particularly in Ceylon—are frequently met with and the children who survive develop various degrees of contractures and deformities. Such accidents could be prevented by designing a better type of lamp or by using the old fashioned coconut oil lamp instead of kerosene oil.

Science has introduced new methods of prevention of disease whereby man can live longer but it has also created new hazards as well as an increased tempo of living. Thus the threat of accidents will increase while the threat of disease will decrease and a definite programme for reducing the frequency of chronic disability from accidents can only be formulated by planned research into accident prevention involving scientists of various desciplines—engineers, doctors, social scientists and biostatisticians. Rehabilitation services should also be improved to reduce the degree of disability following severe injury.

Tuberculosis is a world problem which is responsible for causing death and in the case of survivors, chronic ill health. It is estimated that there are about 65,000 active cases of tuberculosis in the island and in Colombo alone there are, according to an estimate of the Ceylon National Association for the Prevention of Tuberculosis, 5,000 poor tuberculous homes and 25,000 children in these homes who, if unprotected and uncared for, may become the victims of tuberculosis. Although the recent introduction of anti-tuberculous drugs has reduced the mortality from tuberculosis, the morbidity continues to be high. In the prevention of tuberculosis certain features peculiar to the disease should be kept in mind:—(1) In civilized communities the tuberculous germ infects infants and young children and about 75% of the people acquire the infection at this time (2) Unlike in most communicable diseases the germ often remains dormant without producing active disease. This is a dangerous situation because at any time such an individual will break down and without his knowledge infect other people (3) As the human life span increases with the advances made in medical science the opportunity is provided for cases infected in early life to break down into active tuberculous disease (4) The disease is so silent in the early stages that it causes no symptoms by which it could be recognised. During this period tuberculosis can be spread inadvertantly to others. Preventive measures consist in locating people with the tuberculous germs, in isolating them from the rest of the society while they are still infectious, in treating their illness and in the rehabilitation of those in whom the disease is arrested. Protective vaccination with B.C.G. of infants and children is extremely valuable but this alone is insufficient in the absence of other preventive measures that have already been mentioned. Vaccination can be considered successful only if it produces a long and lasting post-vaccination allergy. It has been shown in a controlled trial by the Medical Research Council of Great Britain that such vaccination with a potent vaccine gives 80% protection (1959). It must be remembered that in any community there are people who run a greater risk of developing tuberculosis. These belong to the following categories:—(1) Those who have inactive disease but who have had active tuberculosis within the last 5 years (2) those who have had contact with newly reported cases (3) those who suffer from diabetes (4) those who are receiving steroid therapy for long periods (5) those whose chest x-rays show abnormal shadows (6) those who are obviously losing weight. (7) Those who work in hospitals, sanatoria clinics and laboratories. These categories of persons should be under constant and careful supervision.

It is thus apparent that the only hope for the prevention of such an insidious disease lies in case finding or locating the tuberculous case. Three methods are available:—(1) Tuberculin testing which is valuable in dividing the population into those who are probably not infected and those who almost certainly are infected (2) Photofluorography of the chest which will reveal the condition of the lungs (3) Bacteriological examination of the sputum to determine the case that is infective. Having detected the early case, chemotherapy should be commenced immediately if chronic ill health is to be prevented. Some cases may require hospitalization which, in Ceylon, may not be possible on account of the lack of hospital beds. Quite a large number, however, may be fit for domiciliary treatment. Treatment should be continued for at least two years in the average case and one must ensure that the drugs given in dispensaries and hospitals are actually taken by the patient and not discarded. This is the duty of the social worker and the home visitor. Inadequate chemotherapy not only results in chronic invalidism but also brings about the dangerous consequences of the spread of drug resistant germs in the community.

Arrest of the disease by effective treatment should be followed by rehabilitation of the patient. This is an important aspect of tuberculosis control and is particularly applicable to a poor country like Ceylon. Patients must be found suitable employment in order to keep them free from financial difficulties, or they must be looked after by voluntary organisations or the state who should ensure that they receive a nutritious diet in the absence of which the arrested disease is liable to break down and once again produce active tuberculosis.

Heart disease is a potent cause of chronic ill health. The main causes that bring about chronic heart ailments are *ischaemia*, i.e. an impoverished blood supply to the musculature of the heart, *hypertension* or high blood pressure, acute rheumatism, syphilis, bacterial and congenital diseases. The impact made by rheumatism, syphilis and certain other bacteria on the heart has been reduced to a minimum in the developed countries by effective control in the early stages. The development of rheumatic heart disease accompanied by serious valvular involvement as well as bacterial endocarditis has been prevented by the judicious use of antibiotics in the acute stage. Better hygiene, good housing and less overcrowding have reduced the frequency of streptococcal sore throat—a forerunner of rheumatic carditis and subacute bacterial endocarditis. Similarly the early treatment of syphilis has reduced the frequency of cardiovascular derangements developing in later life and the advance made in the field of genetics has made it possible to prevent congenital cardiac defects. Thus, in the developed countries, while heart diseases caused by these aetiological factors have receded to the background, those due to ischaemia and hypertension have increased. Although in the developed countries much success has been achieved in the prevention of chronic ill health caused by acute rheumatic disorders, in a developing country like Ceylon it has not been possible to achieve such success. Rheumatic heart disease in Ceylon is on the increase as estimated by the large numbers of children and young adults who have been subjected to mitral valvulotomy during recent years. All this could be prevented if more attention is paid by our public health workers as well as engineers to matters of housing and sanitation and a degree of care is taken in the treatment of streptococcal sore throat at home, in schools and in hospitals. Prophylactic use of antibiotics can also prevent many cases of bacterial endocarditis which are secondary to valvular heart disease or congenital heart defects. Serious valvular damage which is a potent cause of chronic ill health in later life can be prevented only if more attention is paid to early diagnosis and treatment—particularly the prophylactic use of penicillin during procedures likely to cause invasion of the blood stream by streptococci.

Hypertension and coronary heart disease are responsible for the greater part of the cardiovascular disease and death occurring in adults. There is some conflict of opinion as to what constitutes high blood pressure, but it is generally accepted that a blood pressure which is persistently higher than 160 systolic and 95 diastolic has to be regarded as abnormal and hypertensive with particular emphasis on the diastolic figure. Also, in the diagnosis of hypertension a case should not be labelled as *idiopathic* or *essential* unless certain factors responsible for this condition are excluded. These include constriction of the aorta or its main branches or of the renal arteries, kidney disease—particularly unilateral renal disease e.g., pyelonephritis, toxaemias of pregnancy, lupus erythematosus and polyarteritis nodosa and such diseases of the adrenals as primary aldosteronism, Cushing's syndrome, congenital hyperplasia and neoplasms.

It is important to discover these causes because the hypertension can be corrected by removal of the cause. The discovery of such causes is not an easy matter because it involves not only a careful clinical examination which should include auscultation of the aorta, measurement of blood pressure in the arms and legs and a search for hairiness or other evidence of masculinization in women but also the biochemical investigation of the urine, serum electrolytes, carbohydrate tolerance, aorto-renal arteriography and if, necessary, surgical exploration and biopsy of the kidney and adrenal gland. After the exclusion of this type of hypertension, there is a large number of cases of high blood pressure for which no cause could be found. At present there is no means of preventing such cases and we have to be satisfied with therapy directed against its progressive effects. It is important for such a purpose to recognise three stages in the disease—(1) High blood pressure without organic changes in the cardiovascular system—Many of us must be suffering from this condition (2) High blood pressure with changes in the heart, such as hypertrophy or increase in size of the heart muscle but without other evidence of organ damage (3) High blood pressure with evidence of organ damage attributable to the hypertension. It has been found that both emotional and environmental stress play major roles in the aetiology of the first stage and preventive therapy aimed at preventing or delaying progress to the second stage will therefore consist of common sense psychotherapy combined with a change in environment but without use of drugs other than sedatives. The early diagnosis of the second stage is important because appropriate treatment may postpone or even avert the serious manifestations of the third stage such as heart failure, blindness, renal disease and stroke. Such treatment consists of a change in occupation, weight reduction, low salt intake and the use of drugs which reduce blood pressure. The prophylaxis of high blood pressure caused by primary renal disease consists of the prevention of those diseases and the adequate treatment of such in their early stages. Both glomerulo-nephritis and pyelonephritis which are the forerunners of chronic kidney disease and high blood pressure are acquired at an early age and it is not fully realized that pyelonephritis plays a major role in their development. This could be prevented by early diagnosis and the proper treatment of urinary infections particularly in children, attention being paid to the condition of asymptomatic bacilluria while the thorough treatment of streptococcal infections will diminish the risk of glomerulo-nephritis.

These measures will to a certain extent reduce the effects of high blood pressure and thus prevent chronic disability caused by this disease. However, it is important to educate the public with regard to the problem

of high blood pressure in such a way as not to provoke undue anxiety but to encourage them to submit themselves to periodic examination and to think over their ways of life.

It is a well accepted fact that ischaemic heart disease i.e. heart disease caused by an inadequate blood supply to its muscle is on the increase in most parts of the world. There are various categories of this condition which causes loss of life sometimes at an early age as well as chronic ill health which may affect one's employment. The three main categories are, angina of effort, myocardial infarction i.e. death of a portion of the heart muscle, and lack of blood supply to the heart muscle without pain. The last condition is diagnosed by the electrocardiogram or it may be revealed by the non-specific effects of heart muscle damage in the form of heart failure, auricular fibrillation or heart block.

Although there are no certain methods of preventing the occurrence of ischaemic heart disease we do know the kind of individual who will have a predisposition to develop this condition. Atherosclerosis i.e. the deposition of fatty patches in the coronary arteries is by far the commonest cause of ischaemic heart disease and the most important from the view point of prevention and control. Unfortunately, the causation of such patches or atherogenesis is a very controversial problem and much research is needed to elucidate its causes. Heredity, hypertension, physical inactivity, stress, occupation, endocrine function, cholesterol content of the diet, and the drinking of soft water are all thought to be operative in the production of atherosclerosis. Certain features, however, stand out prominently amidst this array of factors.

Among these is the fairly well established relationship between cigarette smoking and disease of the arteries which supply the heart muscle. It is of course, well known that smoking is an important cause of thromboangiitis obliterans—a disease in which the blood flow is impaired chiefly in the vessels of the leg. It has been shown from electro-cardiographic tracings that a reduced coronary blood flow, even in the absence of anginal pain, results from smoking (Larson *et al.*, 1961). Smoking also increases the liability to disturbances of the cardiac rhythm (Burn & Rand, 1961). Doll & Hill (1956) have shown a considerable increase in coronary death rates with increasing tobacco consumption in men under 55 years of age and in investigations conducted by Gofman & co-workers (1955) and Karvonen & others (1959), smokers have been shown to have slightly raised levels of cholesterol and other blood fats which, as stated earlier, is associated with increased liability to coronary arterial disease. Lastly, the Committee on Smoking and Cardiovascular Disease of the American Heart Association (1960) has stated that the present evidence "strongly suggests that heavy cigarette smoking may contribute to or accelerate the development of coronary disease or its complications". There is thus ample evidence to incriminate heavy cigarette smoking for the causation of coronary heart disease and it is therefore imperative to make this fact known to the public in the hope that people may change their smoking habits. It is mainly the ignorance of this causal relationship between smoking and arterial disease which has led to inveterate cigarette smoking. There is no doubt that a reduction in the consumption of cigarettes would not only bring about a reduction in the mortality from this type of heart disease but also result in the prevention of chronic disability.

Blindness is a source of great hardship to patients, and anxiety and worry to relatives. Much time and money are spent by the State as well as by social workers to help and rehabilitate the blind. Thus it not only results in chronic invalidism but also in economic loss to the nation. In his Presidential Address to the section on Medicine in 1957, Sivasubramaniam (1957) dealt exhaustively with the problem of blindness in Ceylon. He has estimated that our blindness rate is of the order of about 300 per 100,000 of the population. Although this is a condition met with chiefly in advanced age it is seen at all ages in Ceylon as estimated by Sivasubramaniam in an analysis of 1391 patients attending the eye clinics at Jaffna, Kandy and Colombo. The prevention of blindness is a major problem and should commence with the prevention of certain eye affections contracted in utero by the avoidance of marriages between peoples known to be suffering from hereditary diseases. Careful concentration of oxygen and the length of its administration to premature babies will prevent blindness due to retrolental fibroplasia while attention to maternal health will prevent congenital abnormalities. The proper management of the pregnancy and the labour is also conducive to the prevention of blindness caused by foetal anoxia and by infections at the time of birth of the child. Other methods of prevention of blindness are the early and adequate treatment of conjunctival infections and marasmus, diabetes, high blood pressure, syphilis and gnorrhoea, avoidance of and the early treatment of eye injuries received particularly during industrial pursuits, the correction of refractive errors, the early recognition and treatment of glaucoma and the cessation of the use of pupil dilator drugs as advertised in the lay press as being useful in cataract.

Mental illness in Ceylon is a complicated problem that has to be faced by both psychiatrists and social workers. Unlike certain other diseases which are diagnosed by physical methods, a diagnosis of mental illness has to be made on certain other criteria which require careful observation by psychiatrists. On account of this fact it is not easy to arrive at an accurate estimate of mental illness. However, the recent committee of inquiry headed by Dr. W. G. Wickremasinghe has estimated, on the basis of various surveys conducted in different parts of the island, that there are about 78,000 people in Ceylon who are mentally ill (Wickremasinghe *et al.*, 1966). Nearly 62% of the patients admitted to the Mental Hospital at Angoda are between the ages of 20-29. That mental illness is on the increase is seen by the fact that yearly admissions to the Angoda mental hospital have steadily increased from 1961. The report has drawn attention to the lack of psychiatric services, inadequate nursing facilities, overcrowding in mental hospitals and several other defects too numerous to mention. We are thus faced with the problem of ever increasing mental illness particularly in the young with inadequate facilities for early diagnosis and treatment. In no other sphere of human suffering is prevention more important for, if mental illness can be prevented, we would have accomplished a creditable feat. Unfortunately, unlike in other diseases, the problems involved are much more complex particularly because we are still quite ignorant of the causation of mental disease. The research needed to elucidate the causes has to be carried out by scientists of many disciplines, in laboratories in various parts of the island, and on populations of different cultural, religious and racial backgrounds. Although the task is difficult it is not insurmountable. The problem can be tackled by directing our attention on three spheres of activity.

Firstly research should aim at making a social study of a community scheduled for industrialisation for it is well known that certain stresses and strains which inevitably result in adaptation to a new mode of life are conducive to mental illness. Family life, individual behaviour pattern and the incidence of mental illness should be studied in all aspects. Research should also be conducted on the problems of ageing, the effect of nutrition on mental health and genetics. More knowledge is needed about physical, social and psychological factors that contribute to the occurrence and aggravation of mental disorders in the aged. The part played by nutritional deficiencies—particularly in a tropical population—and by chronic alcoholism and the use of drugs should be more intensively studied. Recent advances made in the study of genetics could contribute to psychiatric prevention and studies on the "chemical pattern" in mental patients and their families should be undertaken.

Secondly, more attention should be paid to the mental health of children for it is well known that childhood environment is partly responsible for mental illness in the adult. We have seen the ill effects of the steady weakening of the parental role and the growing complexity of the social environment on the mental health of children. Stability must be restored by maintaining consistent parental attitudes and a satisfactory parent-child relationship. Social workers should tackle such problems as maternal deprivation—particularly during the first year of life, because such deprivation produces an affectionless psychopathic individual with states of anxiety and depression. Child guidance clinics should be established in various parts of the country and mentally subnormal children should be detected at these clinics and appropriate measures taken.

Juvenile epilepsy should be detected early and treated and juvenile delinquency which represents a failure of education in the home or in the school should be treated by positive rather than punitive measures. Such preventive therapy may be applied to children thought likely to become delinquent.

Thirdly, mental patients should be taken in hand early in the course of the illness and appropriate treatment instituted or otherwise administered before the onset of serious disturbances. The use of psychotrophic agents has to a very great extent eased the management of mental patients enabling many cases to leave hospital for rehabilitation. The advantage gained in the last few years by psychotheraphy should be put to full use in the early treatment of mental illness.

Paradoxical, though it may seem, it has been said that in countries where the health services are good, cancer is seen to be on the increase. An efficient health service enables people to live up to an age at which they become liable to contract cancer. Therefore it stands to reason that, in our country, with the improvement of the health services, the eradication of infective diseases, the lowering of infant mortality and the effective treatment of various illnesses, more and more people will in the future be exposed to the risk of cancer—a lingering disease accompanied by chronic disability. Cancer is essentially a form of disordered growth where the cells of the body multiply haphazardly in a manner contrary

to laws that govern normal growth. Professor Smithers expresses this basic fact in the following terms:—"cancer is not one disease with a cause and cure merely waiting to be found, but the terminal phase of a progression of growth disorganization which can occur in any tissue if its normal control mechanism fails for any reason . . . There is, in fact, no disease of cancer with a cause and a cure all its own for research workers to uncover. But there are a great many variable growth disorders, some of which are serious and others trivial, each variety of which derives in one way or another form some disturbance of the normal mechanisms controlling tissue growth, and most of which are at some stage preventable, reversible, removable or controlable". Although medical scientists are still in the dark about the exact mechanisms of these growth processes in the body and the factors that contribute to disordered growth, yet various epedemiological and experimental studies have shown quite conclusively that certain agents can produce this disordered growth process which we call cancer. In the prevention of cancer these factors have to be borne in mind. For instance, no doubt exists about the carcinogenic effects of ionizing radiation. The relationship between cigarette smoking and the rapidly increasing incidence of lung cancer is universally accepted by medical scientists. Air pollution, whether by factories or by households has been incriminated and many other substances capable of producing cancer have been encountered in chemical industry, mining and other occupations, while there is strong evidence that viruses and hormones may also be responsible for human cancer.

Cancer can thus be prevented by attempting to eliminate or to protect against these environmental factors. This is not so simple and requires the collaboration of several disciplines—Such preventive measures require careful planning and cannot be operated without valid statistics. The absence of statistical records is a great hardship to cancer control and prevention in this country. More data are required on the incidence and prevalence of cancer for which purpose it is necessary to conduct cancer surveys and maintain permanent cancer registers based on hospital data or population.

Another method that is available to prevent the onset of cancer is to detect and treat precancerous conditions. In most countries of Western Europe mass screening is carried out to detect such lesions. In Eastern European countries and the U.S.S.R. more and more extensive examinations of both working and non-working populations are performed each year. It has been found possible to detect precancerous as well as early cancerous lesions in certain locations by detecting the presence of exfoliated cells in body fluids and secretions. This method of exfoliative cytology is particularly applicable to cancers which arise from the uterine cervix, breast, skin, stomach and urinary tract. Unfortunately in Ceylon where there is a very high incidence of cancer of the uterine cervix, mass screening of women by the examination of vaginal smears is not done. This is a matter which should be looked into by the Department of Health Services because considerable suffering and ill health can be prevented if such cancers are detected early and treatment instituted.

In Ceylon the problem of cancer is not so serious as in other parts of the world because at least 70% are preventable. Statistical evidence shows that these occur in the mouth, uterine cervix in the female and penis in the male. The abstension from excessive betel chewing and attention to oral hygiene will eliminate a large number of oral cancers while circumcison will be quite effective against penile cancer. Attention to personal hygiene will prevent a large number of cervical cancers, while mass examination of vaginal smears and the examination of the cervix at postnatal clinics will enable our medical men to detect early cancers in this situation.

Much could be done to prevent the chronic suffering caused by this dreaded disease by early diagnosis, the teaching of which should be a responsibility of medical educators. Unfortunately, attempts at over specialisation have brought about the transfer of cancer patients from general hospitals where students are taught to special cancer hospitals and it is well known that some medical students may go through their whole medical education without seeing a single case of cancer of the mouth, cervix or penis in spite of the fact that haphazard visits are paid now and then to a cancer hospital. This should be rectified early. Early diagnosis is also achieved by educating the public and the general practitioner to be aware of and willing to report possible symptoms. The state should also provide suitable facilities for diagnosis.

The success of the prevention of chronic diseases depends to a very large extent on the degree of familiarity of the community with these diseases. In other words the population at large should be conversant with such diseases—particularly the mode of their onset and the early manifestations. Health education therefore becomes an essential weapon in the prevention of chronic ill health. People could be inspired into

activity only when they are informed about illness and improvement in health and welfare could be maintained by an informed public opinion. Unfortunately in Ceylon, the effect of many traditions and customs as well as of patterns of social organization have created certain misconceptions about disease. These must be removed. This indeed, is a big problem which has to be tackled not only by doctors but also by ethnologists, anthropologists and social psychologists. It is only by the co-operation of individuals of various disciplines that it will be possible to remove the ignorance of the masses in this country regarding disease.

Meanwhile research should be conducted in our Universities and medical institutes into the causation of disease, because preventive methods could be more effectively adopted when the actual cause is known. We should also become more familiar with the intermediate stages of chronic disease processes which invariably occupy almost the life span of the individual. It may then be possible to intervene at a most vulnerable point in the evolution of such a process with appropriate remedies.

I have attempted in this address to indicate some of the problems that have to be faced in the preventions of a few chronic diseases. It will be apparent that the co-operation of both medical and non-medical scientists will be needed for the success of a campaign to prevent these illnesses. Successful results could only be obtained if the activities of several scientific disciplines are co-ordinated. The formation of a National Research Council is the best way to achieve this objective and the members of this Association are therefore very pleased that a bill to set up such a Council is before Parliament.

It may seem at first that preventive measures against chronic diseases and disabilities will involve a large slice of our annual budget but it must be borne in mind that adequate preventive measures will curtail the expenditure involved in building new hospitals, the import of drugs and instruments and also the training of medical personnel. The money thus saved could be utilized for the successful prosecution of plans and campaigns advocated in this address. We must aim at a voluntary coalition of Government, voluntary, and professional health and welfare organisations and agencies. It is only by such efforts could we hope to proceed more rapidly to a more healthful world.

References

American Heart Association (1960). Cigarette smoking & cardiovascular disease. *Circulation*, **22.** 260.

BURN, J. H. & RAND, M. J. (1958). Action of nicotine on the heart. *Br. med. J.*, **1.** 137.

DOLL, W. R. & HILL, A. B. (1956). Lung cancer & other causes of death in relation to smoking. *Br. med. J.*, **2.** 1071.

DARNOVAN, M., ORMA, E., KEYS, A., FIDANZA, F. & BROZEK, J. (1959), Cigarette smoking, serum cholesterol, blood pressure and body fatness. *Lancet*, **1**. 492.

GOFMAN, J. W., LINDGREN, F. T., STRISOWER, B., LALLA, O. DE, GLAZIER F. & TAMPLIN, A. (1955), Cigaretting smoking, serum lipoproteins and coronary heart disease. *Geriatrics*, **10.** 349.

LARSON, P. S., HAAG, H. B. & SILVETTE, H. (1961), *Tobacco experimental & clinical studies.* A comprehensive account of world Literature. pp. 203-206. London: BALLIERE TINDALL & COX.

SIVASUBRAMANIAM, P. (1957), The Problem of Blindness in Ceylon. *Proc. Ceylon Ass. Advmt Sci.*, **2,** 77-95.

Wld Hlth Org. techn. Rep, ser., (1954). **84.**

WHO chron. (1959), **13,** 170.

WICKRAMASINGHE, W. G. ABEYAWARDENA, A. L., FERNANDO, S. E. L., KRISNADASAN, N. (1966), *Mental Health Services in Ceylon Report of the committee of Inquiry.* (Unpublished).

LECTURE BY CHIEF GUEST

THE CHANGING FACE OF MEDICINE

by

SIR MAX ROSENHEIM, P.R.C.P.

Mr. President, Your Excellencies, Ladies and Gentlemen.

I regard it as a very great honour and privilege to have been invited as the Guest Speaker to the Ceylon Association for the Advancement of Science. I thank you most warmly, but am very conscious that I, a mere clinician, cannot do the same justice to the occasion as have the very distinguished scientists who have preceded me.

Let me start by expressing my very real delight at seeing my old friend, Professor G. H. Cooray, as President of your Association. We were students together at University College Hospital over 35 years ago and he returned to U.C.H. after the War to carry out distinguished research under the late Sir Roy Cameron and to carry off the University Gold Medal for his M.D. thesis. We have kept in very close touch over the years and I know that he has not only maintained the same high standard of research, but that he is also an excellent and devoted teacher and that his advice is constantly sought on University and Medical matters.

Since I was last in Ceylon the death has occurred of that grand old man of Ceylon medicine, Professor W. A. E. Karunaratne, a wonderful man who combined skill and tenacity in scientific research with kindliness, humanity and unselfishness in his personal relationships. It was a privilege to have known him well. He qualified as long ago as 1913, and lived through an era of tremendous changes in medical knowledge and practice. He worked at U.C.H. under Professor A. E. Boycott and, last summer, I called on Professor Boycott's widow, who died a few weeks ago at the age of 99. In 1900, at the turn of the century, when she was in her early thirties, she was a ward sister at St. Thomas's Hospital and volunteered to go out to the Boer War with the army. Before she went, and on her return, she was summoned to the presence of Florence Nightingale, so that she was another person whose life spanned the astonishing change from empirical to scientific medicine.

The past forty years have seen the most remarkable advances in scientific knowledge, and these great advances have, of course, been reflected in and accompanied by advances in medical knowledge and practice. Unproven and empirical remedies that had survived through the ages have given way to rational scientific treatment based on a clear understanding of the causes and mechanisms of disease. I discussed some of these changes with doctors in Ceylon a few years ago, but I make no excuse for taking this as my subject today, for what better topic could be discussed with an Association that aims at promoting the advancement of science and, at its Annual Session, promotes contact between scientific workers from various disciplines.

There is no need, and it would be well nigh impossible, to elaborate in detail the great changes that have occurred in medical practice. There is no branch of medicine that has not altered radically since your President and I were students and I shall only touch on a few of the major advances.

It may well be that I shall be the last President of the Royal College of Physicians who can claim to have practised medicine in the pre-sulphonamide and pre-antibiotic era and to have seen the natural history of infection; of pneumonia striking down young adults; subacute bacterial endocarditis that was almost invariably fatal; typhoid, whose victims lay for weeks exhausted by prolonged fever and tuberculosis requiring years of sanatorium treatment and mutilating operations on the chest. What tremendous changes the discovery of penicillin has led to, so that now we have a great range of antibiotics from which, with the advice of the bacteriologist, we can select the best for an infection produced by any specific organism.

As a result of the introduction of antibiotics, and of the remarkable advances in the science and practice of anaesthesia, surgery has become far safer and far more enterprising, so that the surgeon can now replace valves inside the heart can even transplant a heart can restore blood vessels to damaged kidneys, and transplant kidneys into patients dying of renal failure. He can remove cerebral tumours and do remarkable operations on bones and tendons without the fear of infection setting in.

On the medical side, I would select for special mention the advances in endocrinology and in therapeutics. Not only have we recognised the existence of many highly active chemicals circulating in the blood stream, secreted by the endocrine glands, but we have established their mode of action, have worked out their chemical formulae and, in many instances, have been able to synthesise these very potent compounds in the laboratory. This understanding of endocrinology has revolutionised the control of many disorders. The use of insulin in diabetes, of thyroxine in disorders of the thyroid gland, of cortisone and allied steroids in a wide range of diseases and of the various sex hormones are a few examples of the great advances that have occurred.

Following on the discovery of the sulphonamides and penicillin, there has been an enormous expansion of the pharmaceutical industry and the introduction of very many active drugs that we now accept as commonplace, though the story of each is an exciting saga.

This pharmaceutical explosion has led to many problems. These new synthetic chemicals are extremely potent and the doctor today must not only know their action, but also the unwanted side effects and dangers that may accompany their use. The thalidomide tragedy taught us, or reminded us, of the need for the very careful control of the introduction of new drugs, with the need for expert pharmacological study before the first tentative trial in man, and the anxious and widespread watch for any ill effects when the drug is released for use. The discipline of clinical pharmacology has become very important and the clinical trial of new drugs and the controlled comparison of the new with the old calls for great understanding and skill. Despite the difficulties and dangers, there can be no doubt that the pharmaceutical industry has conferred tremendous benefits on our sick.

I am, if I may say so, always disturbed when I find rivalry still existing between the old Sanskrit remedies of the Ayurvedic system of medicine and modern synthetic drugs. I am sure that there must exist active and useful remedies among the older drugs, such as Rauwolfia and its alkaloids, but we now have the means of testing drugs in controlled clinical trials and the value of any drug in any particular disease can be scientifically and statistically determined.

Finally, among the many outstanding advances of recent years, I would select one more for mention, psychiatry. Our understanding of mental processes, of the normal pathway of development and maturity, and of the disorders of the diseased mind is still elementary, but we now accept that the mind can exert an influence on the body, we recognise the existence of specific disorders of the thought processes and we even have drugs that can relieve the split mind of the schizophrenic and rapidly restore the deeply depressed patient to normality. The pharmacology of the drugs that act on the brain, the tranquillisers, the antidepressants and the stimulants has opened a new chapter in our control of disease, while the careful studies of the psychiatrists and psychoanalysts have explained much of our everyday activity and can throw light on some of the underlying differences between individuals, and even between countries, that lead to misunderstanding and strife.

Many of the developments in medicine have, of course, depended upon advances in the basic sciences and upon improved technology. The increasingly close co-operation of biochemists, physicists, engineers and electronic experts with doctors is one of the striking features of present day medicine. Biochemistry was, I suppose, the first of the so-called basic sciences to have a great impact upon medical practice, but when one watches a surgeon operating on the heart, while an intricate pump maintains the circulation, or sees a patient with failing kidneys revive and survive as a result of repeated purification of his blood by an artificial kidney, when one considers the effects of radiotherapy in cancer and the widespread use of radioactive isotopes in investigation and treatment, one appreciates how very dependent medicine has become on other disciplines.

I would emphasise this co-operation for, more and more, medicine depends upon team work with the doctor, the medical man, forming only part of the team. I shall return to this concept when I discuss the doctor in relation to community health; here I am stressing the impact of modern technology on medical practice. There is, I am convinced, a great future for the basic scientist, the physicist, engineer, biochemist or physiologist who wishes to apply his specialised knowledge and techniques to medical problems. We need such people in medicine and must make posts available for them in our large hospitals and research units.

I am firmly convinced that there is no need for the graduate biochemist who wishes to apply his or her knowledge to medicine, to take a medical degree, spending valuable and potentially productive years acquiring an M.B. degree before co-operating in research and investigation. The medical profession should welcome such people to the team, where they can apply their own specialised knowledge and experience and join with the doctors in tackling specific problems. The electronic engineer who organises the equipment that can control the heart rate in patients with heart block, the engineer who has specialised in making artificial limbs, the statistician who demonstrates the relationship between cigarette smoking and cancer of the lungs, do not need to have spent 3-4 extra years in medical education, but must be welcomed as partners in the fight against disease.

There is a tendency, both among the public and among medical students, to think that the glamour of medicine lies in major surgery, in the skilful use of antibiotics and other drugs in the treatment of disease and in the application of modern technology to medicine. These are the triumphs of individual or personal medicine, but the triumphs of public or community medicine are equally dramatic. The actual health—and wealth—of a nation depends far more upon preventive medicine—upon hygiene, immunisation, nutrition and child welfare—than upon the wonderful skill of the cardiac or neurosurgeon.

The prevention of disease—the eradication of poliomyelitis, the control of tuberculosis and the improvement of childhood nutrition will have a far greater impact on the well-being of Ceylon than will a series of the most dramatic operations on children with congenital heart disease or the radical cure of a group of elderly people with cancer. Public, preventive or community medicine—as opposed to individual medicine—is having a tremendous effect on the health of the world.

The medical profession has been slow to appreciate the need for medical students to learn about community medicine. Now, as I shall emphasise in my talk on medical education, we are beginning to appreciate that the teaching hospital and medical school must look outwards and take an interest in the health of the community that it serves. The majority of its graduates will not become cardiac surgeons or super-specialists, but will be responsible for the health of a community. They will have to work as a team with nurses, midwives, health inspectors, dispensers and social workers and must learn the needs of the community not only for personal care, but also for preventive medicine.

When one surveys what is happening in Ceylon, it is clear that here too the picture of disease is changing. I have read with the greatest interest the Report of your Director of Health Services for the year 1963-64 published last year, and would offer my congratulations to Dr. Herath Gunaratna on the evidence of a sustained battle in which the fight against disease is slowly but steadily being won. It is surely a great compliment to Ceylon that Dr. Gunaratna should have been selected to succeed Dr. Mani as South-East Asia Representative of the World Health Organisation in New Delhi.

From his fascinating report I have selected a few high lights. I noted that both the birth rate and the death rate were the lowest yet recorded in Ceylon and that life expectancy at birth in 1962 had increased by about 30 years since 1921—being now over 61 years for both male and female.

Preventive medicine is obviously being very actively pursued. The malaria eradication programme had entered the phase of consolidation. There has been a recent set back and the battle is still being waged. A successful conclusion cannot be far off. The poliomyelitis immunization programme has led to a fall in the incidence from 15.9 per 100,000 in 1961/62 to 1.15 per 100,000 in 1963/64. A B.C.G. programme for the protection of children against tuberculosis is being actively pursued. B.C.G. is also being used in contacts of patients with leprosy and there is an active campaign against Filariasis.

I also noted with great interest that there was a busy programme of public health, sanitation and engineering, that health education was being given high priority and that there is a very successful School of Medical Laboratory Technology.

Preventive inoculation, improved hygiene and better nutrition, quite apart from early diagnosis and treatment, can all lead to great changes in both morbidity and mortality. These represent tremendous advances in the battle against disease, but the skirmishes are not invariably successful. They require the full co-operation of the public and here health education, education of the public in the elements of hygiene and sanitation, in the need for immunisation and in infant welfare is notably important.

Clearly the more money that can be devoted to the prevention, rather than to the cure, of disease, the more healthy will the next generation be. It is always a tremendously difficult decision for any Government to make—how much of the money that can be spared for health should be devoted to improving individual medical care, the health of the present generation, and how much should be spent on prevention, hygiene and nutrition, looking towards the health of the next generation.

It is not always easy to decide why the incidence of any particular infective disease has diminished. One disease that has become rare in the United Kingdom since the war is Rheumatic Fever or Acute Rheumatism. When I was a student, this was very common, a killing disease both in childhood, and in adult life as a result of valvular disease of the heart. It is difficult to determine why it has almost vanished. It had long been recognised as a social disease—a disease that occurred more frequently among the poor, the undernourished and the under-privileged and its disappearance has coincided with the general rise in the standard of living. Antibiotics are, of course, preventing the spread of streptococcal infection, but it seems probable that improvement in overcrowding, in housing and in nutrition have materially contributed to this dramatic change. The gradual change in the disease picture of any country depends upon the altering circumstances of that country, upon the state of nutrition, sanitation, and general standard of living. I know that you in Ceylon are still faced with many infectious diseases, with great problems of hygiene and nutrition, but changes come surprisingly quickly and I am confident that as industrialisation accelerates and as the standards of living improve, the disease picture will alter dramatically.

Unfortunately as the common infective and parasitic diseases become rare, other diseases become more prominent and I propose to spend a little time looking at some of the major problems that we are facing in the United Kingdom. When the population as a whole and the medical profession are largely concerned with the mass of infectious disease, little attention can be spared for two other important groups of disease. At the one end of the disease spectrum are the fascinating genetic and metabolic diseases and at the other end the mass of misery produced by the psychiatric and psychosocial disturbances. The advances in genetics—both biochemical and from the study of chromosomes—have delineated a large group of disorders that must have been present in the past, but were submerged under the mass of acute infectious disease. Similarly the neuroses, depressions and other psychiatric disorders must have existed in the past, though the incidence has probably increased with the greater stress of living in what we euphemistically choose to call "modern civilization".

Apart from these two groups of diseases that have assumed much greater importance, the incidence of certain other conditions has undoubtedly increased with the improved prosperity of the country. There can be no doubt that, in the United Kingdom, we suffer much more from diseases of overnutrition than from those of undernutrition. Obesity, gall-bladder disease and, above all, arterial disease and thrombosis are now conditions of great importance and are related to food intake.

We are faced, in England, with three major epidemic conditions—coronary thrombosis, carcinoma of the bronchus and road accidents. We could do a great deal to prevent each of these. Coronary thrombosis is now extremely common. It affects the business executive and the doctor more frequently than the labourer; the sedentary more than the active. Its incidence is related to food intake, though the exact food is still uncertain, recent work suggesting that a high carbohydrate intake may be more dangerous than fats. The incidence of coronary thrombosis is also statistically related to cigarette smoking. It is, of course, this addiction to cigarette smoking that is undoubtedly responsible for the present epidemic of carcinoma of the bronchus. The relationship between cigarette smoking and cancer of the lung has been very clearly demonstrated in a large number of studies and can no longer be denied. One of the most striking pieces of evidence has been provided by doctors themselves, for they are the one group of people in England in whom the incidence of carcinoma of the lung is not rising and they, unfortunately, are almost the only group of people radically to have reduced their cigarette smoking. The scourge of lung cancer could be very greatly reduced by persuading the public to give up smoking cigarettes and here again health education with all the modern methods of propaganda must play its part.

Road accidents in England and Wales have increased by 66% during the past ten years. We are trying—by building better roads, by stricter speed limits and by greater efforts to prevent people driving under the influence of alcohol also to tackle this modern epidemic.

Two other changes occur as a country becomes more healthy—and more health conscious. As standards of living rise, families tend to become smaller and each child has more love and care devoted to it. Under such circumstances we see the paradox of increasing use of family planning and at the same time the survival of the unfit. The weaklings, children deformed—both physically deformed and mentally retarded—are cared for, nurtured and kept alive. At the other end of the scale, there is an increasing number of old people—often disabled and lonely—requiring much nursing and medical care. Both the homes for mentally retarded children and the geriatric wards for the aged sick make great demands upon nursing—and upon the country's financial resources. There must

be a limit to the number of healthy young girls who are available and willing to devote some of their best years to the care of these two groups of patients—patients who can never be restored to health and who have no useful life before them. These are ethical—rather than medical problems.

What other trends can one note in the present changing face of medicine? I would select only two more for mention. The first is the increasing need for specialisation by the doctors. The advances of medicine have been such that, for a long time, no one man could encompass and practice all aspects of medical care. Of recent years, medicine has tended to fragment into separate specialities—with doctors devoting their lives to cardiology or cardiac surgery, to the intricacies of renal disease, haematology or endocrinology. This undoubtedly results in better treatment and leads to further research and new advances, but it is increasingly expensive in manpower and introduces great difficulties into the organisation of medicine and into medical education. I am afraid that this is a trend that cannot be reversed and we must learn to live with it.

The other trend is our increasing ability to detect disease before it is clinically apparent by carrying out widespread surveys of the apparently healthy population. Two such surveys have long been practised—the routine mass X-ray of chests of populations at risk for tuberculosis, since the disease can be detected before it produces symptoms and can readily be treated in its earliest stages, and the routine use of the Wasserman reaction to detect syphilis in the antenatal clinic for again the adequate treatment of syphilis in the pregnant mother prevents the occurrence of congenital syphilis in her offspring.

More recently it has become possible to detect diabetes before it is clinically apparent by routine testing of urines for sugar and cervical cytology allows the very early detection of those who may later develop cancer of the cervix. Such methods of early detection of disease by mass survey are only likely to be demanded by the public, or to be carried out by the profession, when the general health of the community is high. I would make only two points about this new trend. There is no advantage in detecting a disease early unless there is some effective method of stopping its later development. Detection for detection's sake is useless. Secondly, we must be very careful to avoid the production of mass anxiety as a result of such surveys among apparently healthy people. The surveys must be accompanied by careful explanation and education.

This brings me to the end of my review—and I think that you will all agree with me that the face of medicine is changing—and that we can look forward with confidence to improving health throughout the world—even though new diseases may appear as the older ones disappear.

The Medical Profession is a united and devoted profession—and in its battle against disease recognises no frontiers. If all the countries in the world could unite and pull together as well in the political as they do in the medical field, peace and security would be ensured. Through the World Health Organization, the countries of the world unite in the exchange of information, in the discussion of advances and of methods of attack, in the education of doctors and specialists and in the provision of help—both in finance and in medical and para-medical personnel in the fight against all forms of disease. There has never before been seen such a superb international organisation—in which the public health and medical professions of more than 120 countries exchange their knowledge and experience and collaborate in an effort to achieve the highest possible level of health throughout the world.

SECTION A—MEDICAL AND VETERINARY SCIENCES

Presidential Address

"THE PROPER STUDY OF MANKIND....."

by

A. S. DISSANAIKE

I must first apologise for the rather abstruse nature of the title of my address. It has been chosen with apologies to Alexander Pope. You will perhaps remember the famous lines from his "Essay on man" written in 1733—

'Know then thyself, presume not God to scan;
The proper study of mankind is man'.

For some obscure reason these words have been ringing in my ears ever since I first read them, and a few months ago, in fact after I chose the title of my address, I came across a book entitled "The Proper Study of Mankind" written by Stuart Chase (1957). It was an inquiry into the science of human relations, and the author took the side of Pope. For many years now I have come to realise that when we are dealing with the medical sciences and particularly when we study the parasites of man, we have to go a step lower and differ from the poet by concluding that the proper study of mankind is not man—but animal, and this is the main theme of my address today.

What I wish to present to you then is that no proper study of the parasites of man can be undertaken without a study of the parasites of animals, or to put it in the words of a well known helminthologist of the past, Arthur Looss (1911) "What I wish here to emphasize is that a correct knowledge of the diseases of man caused by worms, and all that is connected with them, is the more difficult to attain the more the parasites of animals are ignored".

It is not my intention to deal with such things as the value of animal experiments in chemotherapeutic trials, nor of the immense advances made in our knowledge of human parasitology by studying the details of the life cycles of animal parasites. We are all aware that most of the drugs now used for the treatment of malaria, filariasis and the intestinal parasitic infections have been first tried out on animals. It is equally well known today that the liver cycle of malaria parasites was first elucidated in the monkey parasite *Plasmodium cynomolgi*. I shall rather be discussing the importance of parasites of animals as parasites of man.

Although the organisms that parasitize man comprise the arthropods, the helminths, the protozoa, the spiral organisms, the bacteria, the rickettsiae and the viruses, I shall confine myself to the protozoa and helminths, which are after all the only organisms I am concerned with. Some of these parasites were acquired by man quite early in human history from dogs and pigs and other animals that he domesticated; others, directly or indirectly from wild animals, and still others he continues to acquire from wild and domestic sources (Cameron, 1962).

How does man, or for that matter any animal become infected with a parasite? There are two main methods. Quite a few parasites enter the human body by the oral route, the parasite being taken in with food or water contaminated with or containing the infective stage. The remainder enter the body through the skin gaining entry either by their own efforts, like the larvae of hookworms, or being brought to the surface of the skin by blood sucking arthropods which are responsible for helping them into the skin. The malaria parasites and the filarial worms are good examples of the latter.

I shall presently be taking you through man's environment, first his immediate domestic environment and then a little further out and finally to the jungles into which he often ventures, and shall discuss as I go along some of the protozoa and helminths that he may acquire. Before doing so I would like to make it quite clear to you that only a handful of man's parasites are entirely his own, by which I mean that they are specific or peculiar to him. Among these are two of his malaria parasites *Plasmodium vivax* and *P.ovale*, one of his filarial worms *Wuchereria bancrofti* and perhaps his hookworms. All other parasites that we come across in medical parasitology are shared by man with other animals and comprise the so called zoonoses.

Zoonosis is a term which has been known from the early times of Virchow and has been variously defined since then, but it was Heisch (1956) who first pointed out that it is only when infections are common

to man and animals that we can really refer to them as zoonoses. He criticised the definition given by the First WHO/FAO Committee (1951) according to which zoonoses are "those diseases which are naturally transmitted between vertebrate animals and man". As pointed out by Heisch one cannot always recognise disease in an animal, for instance one cannot say whether an armadillo has a headache! He suggested the term infection instead of disease and accordingly the Second Joint WHO/FAO Committee on zoonoses (1959) modified the definition to "those diseases and infections that are transmitted between vertebrate animals and man". Nelson (1960) stressed that the general term zoonosis is inadequate when referring to a particular infection in a particular locality, since it gives no indication of the direction of transmission nor of the main host of the organism involved. Garnham (1958) first suggested the division of zoonoses into two main groups—the *Euzoonoses* and the *Parazoonoses*. The former are those in which man occupies an essential part of the life cycle of the infective agent. As far as is known today the two tapeworms of man *Taenia solium* and *T.saginata* alone belong to this category. Garnham pointed out that these differ from the other zoonoses in that if the parasite is destroyed in man it will soon die a natural death.

The remaining infections Nelson defined as follows:—

(*a*) *Anthropozoonoses* are those infections of man naturally acquired from other vertebrates where the maintenance host is animal and man is the incidental host.

(*b*) *Zooanthroponoses* or infections of vertebrates naturally acquired from man where man is the maintenance host and animals are incidental hosts.

(*c*) *Amphixenoses* or infections naturally transmitted between man and other vertebrates, the infection being maintained by either man or animal.

The organisms in this group have a wide host range and are adapted to man or animal and there is free interchange between these hosts since their intermediate hosts are neither strictly anthropophilic nor zoophilic, according to Nelson.

He also stated that amphixenoses stress the dynamic aspect of zoonoses and quoted the famous example of Yellow fever from Africa which

I quote in his own words "Originally in Africa it was probably an anthropozoonosis, man being an incidental host, but with the increase in human population it became an amphixenosis, the infection could then be maintained by either man or monkeys. When it was introduced to S. America it was probably first confined to man in coastal towns, but later a zooanthroponotic episode resulted in monkeys being infected; these were incidental hosts and epizootics killed off many howler monkeys. Before the Rockefeller Foundation got to work, there was probably some degree of stability, and as in Africa, the virus was being maintained either in man or monkeys as an amphixenosis. With the introduction of effective vaccination and *Aedes* control, man is no longer an efficient maintenance host and the present sporadic cases represent anthropozoonoses". (Fig 1).

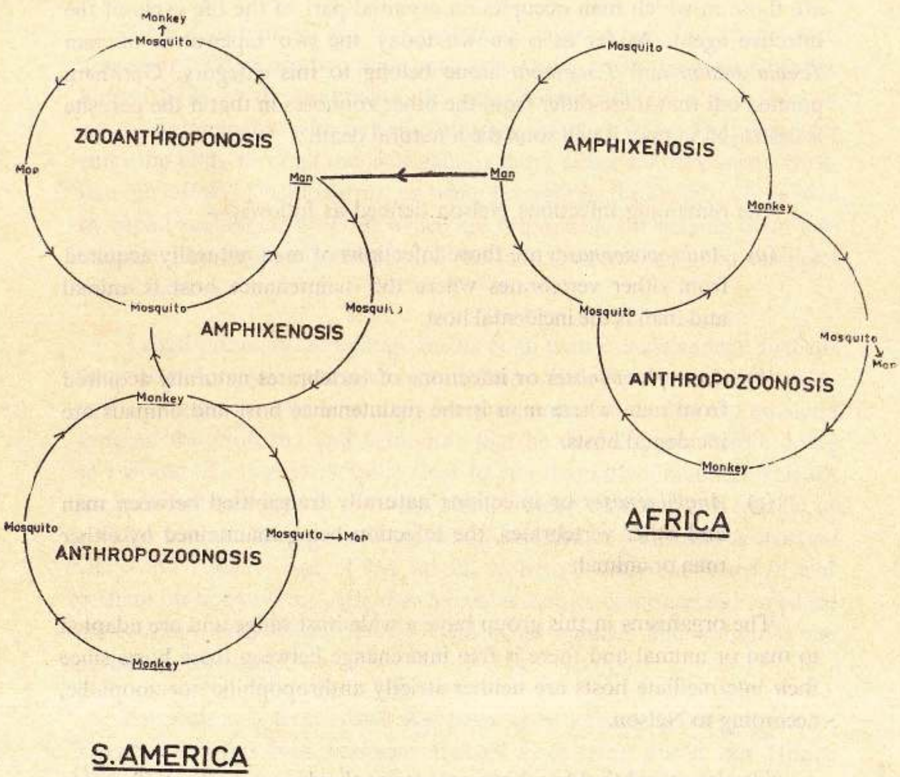


Fig. 1

We are no longer satisfied then by confining our attention to the transmission of parasites between human beings, but in many instances must ask ourselves the question, "Is this a Zoonosis, and what type is it?" Many diseases that were once believed to be of 'unknown aetiology' are now known to be infections, often abortive with organisms from animals.

DOG AND CAT ROUNDWORMS AND HOOKWORMS

Let us now consider the parasites that man may acquire from animals in Ceylon. The animals in his immediate domestic environment will be responsible for what we can refer to as the domestic zoonoses and the only ones of importance here are cats and dogs. Cats and dogs have their own roundworms and hookworms. *Toxocara canis*, for instance, is a roundworm that lives in the small intestine of the dog and has a life cycle similar to the human roundworm *Ascaris lumbricoides* but more complex in many respects. Eggs of this worm are passed to the exterior with the faeces of the dog and develop to the infective stage in 2-3 weeks. They hatch when swallowed by a dog, and in its intestine the second stage larvae penetrate the wall and travel via the portal circulation to the liver and later to the lungs. In dogs under three months old they break through the lung capillaries, go to the trachea and are swallowed back to the intestines where they mature to adults in about a month. In dogs over 6 months old however, they proceed via the systemic circulation to almost any part of the body where they remain alive, but dormant, for long periods. Curiously enough more larvae make this journey in the female and these second stage larvae that have encysted in the tissues are stimulated and mobilised during the development of lactation and are carried by the blood stream through the placenta to the foetus. Hence the pups when born are already infected although the mothers had no apparent intestinal worms. At birth these worms are only in the lungs of the pups but migrate to the intestine after a week or so.

When infective *Toxocara* eggs are swallowed by children, the larvae after hatching out and getting into the portal circulation, do not as a rule go back to the intestine but undergo somatic migrations, and wherever second stage larvae settle and encyst they produce lesions often of a serious nature. The organs frequently involved are the liver, lungs, brain, eyes and perhaps muscles. Histological reactions are characteristically tissue reactions to wandering larvae and are eosinophilic granulomata around or in the trail of the worm, frequently containing Charcot Leyden crystals and sometimes followed by fibrous encapsulation.

Infection of man, particularly children of the toddler age group, by larvae of *Toxocara* was first recognised by Beaver and his associates (1952) in the United States who suggested the term '*visceral larva migrans*' for the pattern of lesions due to the migrating larvae in the body and within the viscera. Many of the subsequent case reports have also been from the United States but the disease is no doubt cosmopolitan since the parasite in dogs (and cats) is widely distributed, and repeated warnings have been given of the danger of infection of children of the 'dirt eating age group'. The presence of larvae results in recurrent fever, leucocytosis with high eosinophilia, raised gamma globulins, hepatomegaly, splenomegaly and sometimes subcutaneous nodules, which are therefore common features of this syndrome. In older children and adults ocular involvement is more common with resultant squinting, visual disturbances and even blindness, and many an eye has been enucleated after a diagnosis of retinoblastoma has been made. Usually one eye is involved and there is a solitary white unilateral granuloma in close proximity to the optic disc or macula with signs of endophthalmitis. These eye manifestations were first reported by Wilder (1950) from the United States, and have subsequently been well illustrated by cases from Great Britain (Ashton, 1960; Irvine and Irvine, 1959; Duguid 1961; Harris, 1961).

The suggestion has been made that larvae of *Toxocara*, and perhaps other nematode larvae too, may be responsible for transmitting viruses and other microorganisms to the brain, resulting in encephalitis. Mochizuki and others (1954) demonstrated experimentally that migration of *T.canis* larvae to the brains of mice was effective in initiating a condition which facilitated the localization of the virus of Japanese B encephalitis and they and many others have drawn attention to the well known report of Beautyman and Woolf (1951) where there was a possible connection between the migration of an ascarid larva (probably *Toxocara*) and the development of poliomyelitis in a child. Many authors have also quoted the paper of the late Professor P. B. Fernando and Dr. Balasingham (1943) who in a series of 162 cases of acute ascariasis found 14 cases suggestive of encephalitis and one of meningitis. It is possible that in all these cases the migrating larva affects the blood brain barrier and facilitates the passage of the virus, or takes the organism along with it, or even potentiates a latent virus in the host.

More recently, Woodruff and Thacker (1964) endorsed these views while Brain and Allan (1964) reported a case where they believed that encephalitis was due to *Toxocara* infection. Woodruff *et al.* (1966) by use of a skin sensitivity test found that more persons who had poliomyelitis or epilepsy gave positive reactions to *Toxocara* antigen than apparently normal people, confirming as they believed that *T.canis* and *T.cati* larvae (of the dog and cat respectively) in their migrations from the lumen of the alimentary canal to the blood and tissues carry with them microorganisms. Also Becroft (1964) in New Zealand attributed a case of fatal myocarditis in a 15 month old child to *Toxocara canis* infection since he identified a larva in granulomatous lesions in the liver at autopsy. There was no evidence in this case of larval invasion of the myocardium but a hypersensitivity reaction or potentiation of a viral infection by the parasite was considered possible. Frankish (1965) in a report of a surviving case from the same country saw *Toxocara* larvae in the liver, but felt that there was possible evidence of parasitic infiltration of the cardiac muscle.

In Ceylon it has been found that nearly 50% of dogs in Colombo (Dissanaike, 1961) and over 80% of puppies in Peradeniya (Seneviratna, 1955) are infected with *T.canis* while *T.cati* is also common in cats (Seneviratna, 1955 a). These worms are therefore sufficiently common in Ceylon to leave no doubt in our minds that children here can and must get infected. Although we have had no cases reported from Ceylon so far, this is understandable since there is not sufficient awareness of the condition and also because the only way of diagnosing it with certainty is to demonstrate *Toxocara* larvae in tissue sections of organs involved, by open biopsy or at autopsy.

Another interesting fact that has emerged very recently is that faeces from a cat infected with *Toxoplasma* continued to infect mice with the same organism for longer periods than it could normally have been expected to, provided that the cat was simultaneously infected with *Toxocara cati* (Hutchison, 1965 and 1967), an observation which has been confirmed by others. The suggestion is that *Toxoplasma* is transmitted in the eggs of *Toxocara* in the same way as a flagellate of turkeys, *Histomonas meleagridis* is transmitted in the egg of the nematode *Heterakis gallinae*. *Toxoplasma* is a protozoan parasite which has relatively recently come into the limelight and is responsible for a variety of conditions in man. The reservoir hosts of human infections are known to be various animals but particularly dogs and cats, and its mode of transmission has not up to now been clearly understood. The importance of this finding to us lies in the fact that *Toxoplasma* is common in cats and dogs in Ceylon in addition to other animals (Kulasiri, 1962, Kulasiri *et al.* 1965, 1967), and Kulasiri (1967) has recently isolated the organism for the first time from an authentic human case.

When the larvae of hookworms of cats and dogs enter the human skin they give rise to the classical type of '*cutaneous larva migrans*' or '*creeping eruption*'. It is characterised by a continuous progressive linear eruption of the skin, the offending larva being at the progressing end of the lesion. Observations have been made on infections of this type from experimental or accidental entry of larvae of cat and dog hookworms like *Ancylostoma braziliense* and *A.caninum*, which incidentally are extremely common parasites of our dogs and cats. In fact nearly every dog in Ceylon has hookworm infection (Dissanaike, 1961). In natural cases of 'creeping eruption' so far, the larvae have not been identified but they no doubt belong to the above species. Strangely enough here again no cases have been reported in the literature in Ceylon although they no doubt exist. I have myself come across several cases in foreigners in Ceylon who have suffered from this condition, the results of treatment of which are very disappointing. The best known effective treatment is the freezing of the progressing end of the larva to cause sloughing of the epidermis. This condition is not a serious one though it can be quite annoying. However it is believed that some of these larvae causing creeping eruption later invade the deeper tissues and are responsible for one form of visceral larva migrans.

Two other important parasites from dogs have to be considered, namely *Echinococcus granulosus*, which gives rise to hydatid cysts, and the filarial worms, which are believed to be responsible for Tropical Pulmonary Eosinophilia. The former, I shall take up with the sylvatic parasites and the latter will now be considered under the heading Filarial Zoonoses.

FILARIAL INFECTIONS AS ZOONOSES

Of the filarial parasites of man only two have been found in human beings in Ceylon namely *Wuchereria bancrofti* and *Brugia malayi*. The latter was till relatively recently considered to belong to the same genus as *W.bancrofti* till Buckley in 1960 created the new genus *Brugia* for three parasites of cats and dogs that had a similar morphology and similar microfilariae with tail nuclei. Since then over half a dozen species of *Brugia* have been discovered from various parts of the world (Table 1). Two of them have been found in Ceylon, one from dogs and cats (Jayewardene,

TABLE I

BRUGIA SPECIES OF MAN AND ANIMALS

	Hosts	*Country*
B. malayi	Man, Monkey, Cats.	India, Ceylon, Malaya.
B. pahangi	Cat, Dog, Tiger, Civet, Monkey? Man.	Malaya.
B. patei	Cat, Dog, Genet, Lemuroid.	E. Africa.
B. buckleyi	Hare.	Ceylon.
B. ceylonensis	Dog, Cat.	Ceylon, India.
B. beaveri	Raccoon? Lynx.	S. America.
B. guayanensis	Coatimundi.	S. America.
B. tupaiae	Tree shrew.	Malaysia.
B. sp. (Timor)	Man.	Port of Timor.
B. sp. (Rhodesia)	Civet.	Rhodesia.

1962, Abdul Cader, 1966) called *B.ceylonesis* and one from the Ceylon black naped hare, *B.buckleyi* (Dissanaike and Paramanathan, 1961). The interesting thing about the Brugias of animals is that some of them can be transmitted to man, namely, *B.malayi* and *B.pahangi*; while the latter have also been shown experimentally to give rise to Tropical Pulmonary Eosinophilia (Buckley, 1958). In this connection it is of interest to note that *B.buckleyi*, unlike the other filarial worms, that are found in the lymphatics is found in the heart (right ventricle) and pulmonary arteries. Following the discovery of this worm in Ceylon, workers in Liverpool (Edeson *et al.*, 1962) infected cotton rats and hamsters with *B.pahangi* and *B.malayi* and found that the adult worms were present in the heart in addition to the lymphatics. One is therefore tempted to ask the question, does this possibly happen with *W.bancrofti* in man and if so what are the implications of such a possibility? This certainly is something worth investigating.

It must be remembered that man is exposed to a variety of infective filarial larvae of animals especially cats and dogs and in Ceylon the common worms are *Dirofilaria repens* and *B.ceylonensis* mentioned earlier. Filarial larvae of animals are known to cause serious effects in man although the larvae fail to develop into adults and produce microfilariae. Nelson refers to them as the 'abortive filarial zoonoses' and these are similar to the abortive mematode zoonoses produced by roundworms and hookworms of cats and dogs causing 'larva migrans' that were discussed earlier. That filarial worms going the wrong way in the wrong host can cause serious pathological lesions was first pointed out by Innes and Shoho and others. *Setaria* species of cattle, they showed, can cause extensive paralysis in goats, sheep and horses and Innes and Shoho (1952) even suggested that many neurological syndromes of unknown aetiology in man in tropical countries could be due to the so called cerebrospinal nematodiasis caused by these setarias, but, as pointed out by Nelson (1965) any filarial worms of animal origin can produce similar lesions, and perhaps some of our obscure neurological syndromes are due to them.

Other pathological lesions due to filariae of animals going the wrong way in man include T.P.E. and subcutaneous tumours or cysts due to *Dirofilaria* spp. of dogs and cats.

TROPICAL PULMONARY EOSINOPHILIA

T.P.E. is a condition we are all familiar with. In most patients the chief complaint is cough, associated with breathlessness occurring in

paroxysms especially at night. A persistent eosinophilic leucocytosis of more than 2000 eosinophils per c.mm. is present in all cases and the E.S.R. is raised. A striking feature is the prompt clinical improvement and a sharp decrease in the eosinophils following treatment with diethyl carbamazine. Also the C.F. test using filarial antigen is positive in high titres before treatment, falls rapidly after treatment, and becomes negative as the eosinophilia comes to normal, usually within 2-4 months. The picture suggested an occult filarial infection of animal origin as the cause of this syndrome and this view was confirmed in the experiments of Buckley (1958) when volunteers were infected with *B.malayi* and *Brugia pahangi*. He expected them to develop filariasis and show microfilariae in blood—instead they showed up as typical cases of T.P.E. However the findings of Webb (1960) in Vellore and those of Danaraj (1966) more recently, where microfilariae which were morphologically like those of *W.bancrofti* were demonstrated in tissues including lymph nodes and lungs in cases of T.P.E., although the blood was negative, suggest that some cases are due to infection with *W.bancrofti* itself which for some obscure reason has become occult and manifests itself as T.P.E.

There are numerous records of *Dirofilaria* worms of animals, particularly of dogs in subcutaneous cysts and nodules in man and we have had two cases already reported from Ceylon. The first case was of an immature female *Dirofilaria* (probably *repens*) in a cyst of the chest wall of a boy in Ragama (Wijetilleke *et al.*, 1962) and the second worm was recovered from an adult in Colombo who had the worm in a subcutaneos cyst of the arm (Ratnavale and Dissanaike, 1964) This worm was a male and was definitely identified as *D.repens*. Recently a case has come to our notice of a lump in the right parotid region of a patient from Dedigama, where the worm was discovered by us only on histological examination of the tissue (Attygalle and Dissanaike, 1967). The measurements and morphological features of the worm in section suggest that it is an immature female *Dirofilaria*, which is once again probably *D.repens*. These are only three cases that have come to our notice in the last few years and no doubt many others have gone unnoticed and unidentified in the past.

PARASITES FROM RODENTS AND SMALL MAMMALS

Rats, bandicoots and other related small mammals though they cannot be considered as domestic animals are important reservoirs of parasites that can infect man. I shall discuss two of them that have been found as relatively common parasites in these animals in Ceylon.

Capillaria hepatica is one of these parasites which has a fairly world wide distribution. It is closely related to the human whipworm *Trichuris trichiura* but differs chiefly in the fact that the adults are found in the liver and eventually die there leaving their eggs, which are responsible for the lesions in this organ. The life history of this parasite is as follows. When the infective eggs are swallowed by a suitable host they hatch out in the alimentary canal. The larvae burrow through the wall of the intestine and reach the liver either through the portal stream or through the peritoneal cavity. The rest of the life cycle as far as it is known is as follows. Carnivorous animals disperse the eggs by their droppings since undeveloped eggs pass through the alimentary canal without hatching. Cannibalism on the part of a rodent host may in the same way help in spread of the infection. Once the eggs reach the soil they develop to the infective stage. When such infective eggs are swallowed by suitable hosts infection takes place. Decomposed livers of parasitised animals may contaminate food and they develop to the infective stage there.

The liver of the common bandicoot in Ceylon was first found to be infected (Dissanaike and Paramananthan, 1961a) and later this parasite has been seen by us in the liver of the rat, *Rattus rattus*, the palm squirrel, and the common Ceylon hare. In the rat, bandicoot, and squirrel the livers were seen to be studded with yellowish white patches or tracts which contained masses of typical eggs. The egg of *Capillaria* is similar to that of the whipworm, barrel shaped and the thickened shell has a opening at each pole closed by a plug. The outer layer shows characteristic rod like striations ending on the surface in refringent knobs, giving a radially striated appearance to the egg which helps to distinguish it from the whipworm egg. The contents of the eggs in the liver are either unsegmented or in the 2-8 cell stage. Two hares that were shot in Dehiwala showed marked cirrhosis of the liver and *Capillaria* eggs were seen amongst the fibrous tissue. Sections of the livers of the bandicoots and the hares were sent to the late Sir Roy Cameron who was interested in the response of tissues to helminth eggs, in 1961. He was surprised to note "little fibrous tissue production and yet plenty of eggs in the bandicoot liver in contrast to the hare livers". He imagined that "either there had been considerable destruction of these eggs with liberation of irritant substances in the case of the hare, or else some complicating factor like infection which had modified the response very considerably in these animals" (Cameron, 1961).

Human infection has been reported from time to time. The first case was recorded by Mc Carthur (1924) from a British soldier who had been to India for 3 years. Since then several human infections have been reported from New Orleans, N. Carolina, Turkey and Africa. In a case reported by Otto *et al* (1954) there was massive hepatic infection where the liver was severely damaged and, two years after infection there was a diffuse cirrhosis with large numbers of intact eggs. The patient at autopsy showed lesions of acute myocarditis suggesting perhaps a hypersensitivity to the parasite. Most of the cases have been diagnosed only at post-mortem. However it is important to realise that *Capillaria* infection can occur in man in countries where infection is known to occur in animals. According to Balfour (1925) almost all human infections result from association with infected vermin but Cochrane *et al* (1957) showed that infection is always acquired by accidentally swallowing infective eggs from the soil. Lubinsky (1956) has stressed that infections with this parasite may be a possible cause of cirrhosis of the liver in Canada. It is quite likely therefore that human infections may occur in Ceylon especially in toddlers who readily swallow eggs from the soil. High eosinophilia, hepatomegaly, and hyperglobulinaemia may be seen in such cases.

EOSINOPHILIC MENINGOENCEPHALITIS

An outbreak of an unusual form of meningoencephalitis characterised by the presence of many eosinophils in the cerebrospinal fluid was recorded in an Island in the Pacific Ocean in 1948. Subsequently large numbers of cases have been found in other widely separated Islands. This eosinophilic syndrome is characterised by distinct meningeal symptoms, relatively short duration, absence of limb paralysis and termination in complete spontaneous recovery (Rosen, 1967). In 1961 a lungworm of the rat *Angiostrongylus cantoneasis* was incriminated as a causal agent of this condition in a patient in Hawaii where the worm was recovered from the brain. Interest in this field originated with the theory proposed by Alicata and others that this worm might be the aetiological agent. However this parasite was first recovered from a man in Taiwan in 1944, several adult worms being recovered from the C.S.F; but the paper was in Japanese and was not known till recently. Other evidence in support of the fact that this worm is the causal agent were the ability of the larvae to travel to the central nervous system of simian primates and produce eosinophilic meningoencephalitis, reports of two human cases following the wilful ingestion of raw slugs from endemic areas, presence of the rat lungworm in all the Pacific Islands from which cases of eosinophilic meningoencephalitis have been reported, high incidence of eosinophilic meningoencephalitis in Tahiti where raw prawns are eaten, widespread incidence of the disease in certain areas of Thailand where insufficiently cooked and preserved snails are consumed and the absence of human cases where the parasite has not occurred in animals. (Alicata, 1965).

The life cycle of this worm elucidated by Mackerras and Sanders, (1955) is briefly as follows:—It utilises molluscs as intermediate hosts, and the definitive hosts in nature are rats and related rodents. Adult worms live within the pulmonary arteries where females lay eggs which lodge in the smaller branches of these arteries. When the eggs hatch the first stage larvae break through, migrate to the trachea, enter the alimentary canal and are passed out in the faeces. Further development takes place only if these first stage larvae are ingested by, or penetrate into the body of the intermediate host which is a terrestrial or aquatic snail or slug. Within the tissues of the snail the larvae undergo two moults and become third stage or infective larvae after a couple of weeks. These remain viable in the snail for long periods probably as long as the snail lives. When the snail host is eaten by a suitable definitive host the larvae are liberated in the intestine and migrate to the central nervous system via the blood stream. Here, within the brain parenchyma they undergo two moults and after about two weeks emerge on to the surface of the brain. In another two weeks these young adult worms migrate to the pulmonary arteries and in a weeks time become sexually mature.

A.cantonensis is a relatively non specific parasite and when its infective larvae are ingested by mammals which are not suitable definite hosts they migrate through the central nervous system, moult in the brain and even emerge on the surface of the brain as young adults. In these abnormal hosts however they either die in or on the surface of the brain and never reach the pulmonary arteries. Reaction to the dead parasite is the cause of clinical signs and symptoms observed when man becomes infected with this parasite.

Joseph Alicata who has done a great deal of work on this parasite recently visited Ceylon and reported that he found it in about 64.3% of our bandicoots in Colombo (*Bandicota malabarica*) and 2.8% *Rattus-norvegicus* (Alicata, 1966). We have since found it quite frequently in bandicoots and the female worms can be easily recognised as their bodies show the very characteristic barber's pole appearance. The snail vector

in Ceylon has not yet been found but there is no doubt that it is the common Kalutara snail *Achatina fulica* which is a recognised intermediate host in other countries where it is known as the giant African snail.

According to Alicata (1965) the sources of human infection are not fully known at present but some infections are the result of intentional consumption of raw or inadequately cooked molluscan intermediate hosts. In the Pacific Islands most infections are believed to be by consumption of small molluscs of terrestrial planarians on raw green vegetation or from intentional consumption of raw fresh water prawns or crabs. The latter animals and the planarians are regarded as paratenic hosts of the parasite. Infective larvae of this parasite are also known to escape from the molluscan tissues when they are injured and the possibility of infection occurring through contaminated water does exist although it is a remote one. Larvae may escape into the soil too by this method and entry of larvae through the skin has also to be considered as it has been shown to be a possible method in experimental rats. Although we are not in the habit of eating anything raw or undercooked in Ceylon, least of all snails and slugs it is necessary to realise that the possibility of infection occurring in Ceylon does exist by the larvae being accidentally ingested with vegetables in which free larvae or larvae in damaged snails or slugs are present.

I am sure there are many cases of high eosinophilia where the symptoms and signs suggest infection with this parasite in Ceylon and it would be useful if clinicians look for increased eosinophils in the C.S.F. in addition to some typical clinical features of the infection. In older children and adults the condition is believed to be characterised by headache, paraesthesias and variable degrees of nuchal rigidity, while cranial nerve palsies occur in a few cases. In younger children and infants higher degrees of fever and irritability are common, and these features can remain for long periods. A diagnosis can generally be confirmed by staining the C.S.F. for Eosinophils.

SIMIAN MALARIA

In 1960 Don Eyles and his colleagues in the United States discovered that man can be infected with one of the malaria parasite of the lower monkeys of Malaya by the bites of infected mosquitoes. This discovery was quite an accidental one. The malaria parasite was *Plasmodium cynomolgi bastianellii* a subspecies of the monkey parasite *P.cynomolgi* on which the well known work on the liver-cycle was done. It has a close resemblance to the human *P.vivax*. The infections that occurred were in a laboratory in the United States and were obviously mosquito induced. A series of experiments were then conducted in prison volunteers in Atlanta Georgia and it was demonstrated that *P.c. bastianellii* will infect most men and produce clinical symptoms and that the original M.strain of *P.cynomolgi* can also infect man, an observation that has since been confirmed by others. It was also shown later that both parasites can be transmitted from man to man not only by infected blood but by mosquito bites as well. Thus, it was shown that monkey malaria is a potential zoonosis. The WHO Expert Committee on Malaria in its 8th Report viewed this with some concern and WHO and other organizations set out to encourage research on Simian Malaria parasites and from that time there has been an outburst of discoveries of monkey malaria parasites in different countries. For instance about ten years ago only three difinite species of malaria parasites were known in monkeys in Asia, but today there are well over half a dozen species. They are summarised in the table below. (Table 2)

Prior to the discovery of Eyles and others. *P.knowlesi* and *P.inui* and *P.schwetzi* and *Plasmodium* sp. from an African monkey had been transmitted to man by blood inoculation. In 1963 (Contacos *et al.*) *P.brasilianum* a quartan type parasite of the New world monkeys was shown to be infective to man by the bites of infected mosquitoes, and Coatney *et al.* (1966) reported that *P.shortti* is transmissible to man by mosquito bites. But the first report of a naturally acquired malaria infection in man transferable to monkeys was by Chin *et al.* (1965) who on the basis of its morphology, quotidian periodicity and infectiousness to rhesus monkeys identified the parasite as *P.knowlesi*. This was the first proof that simian malaria is a true zoonosis. These authors pointed out its possible significance in the context of world wide malaria eradication programmes and more recently Deane *et al.* (1966) demonstrated the second case of this type where a human being was infected with *P.simium* in the outskirts of the city Sao Paulo, Brazil where human malaria does not exist.

However as pointed out by Bray (1963) the possibility of monkey malaria becoming endemic in man is remote, and it is the sporadic case like the two recorded above that is likely to occur where man 'blunders into a closed animal-host-parasite-vector system'. The justification of this, as Bray points out, is that as a rule the vectors of monkey malaria

TABLE II

Plasmodium spp. OF MAN, APES AND MONKEYS

	MAN	HIGHER APES		LOWER MONKEYS					
Periodicity		AFRICA	ORIENT	S.AMERICA	AFRICA	CEYLON	INDIA	MALAYSIA	TAIWAN
24 Hour (Quotidian)								*P. knowlesi*†* *P. k. edesoni*	*P. k. arimai*
48 Hour (Tertian)	*P.vivax* *P.falciparum* *P.ovale*	*P.schwetzi*† *P.reichenowi*	*P.pitheci* *P.hylobati* *P.youngi* *P.eylesi* *P.jefferyi*	*P.simium**	*P.gonderi*	*P.c.ceylonensis* *P.cynomolgi* "Langur" *P.fragile* *P.simiovale*	*P.c.ceylonensis* *P.fragile*	*P.cynomolgi*‡ *P.c.bastianellii*‡ *P.coatneyi* *P.fieldi*	*P.c.cyclopis*
72 Hour (Quartan)	*P.malariae*	*P.malariae* (=*P.rodhaini*)		*P.brasilianum*‡		*P.shortti*	*P.shortti*‡	*P.inui*	

Key to Sign:- * Transmitted to man in nature. ‡ Transmitted to man through mosquitoes (Lab). † Transmitted by blood inoculation.

are generally zoophilic rather than anthropophilic, in other words that mosquitoes normally feeding on man are unlikely, to be concerned in normal transmission of monkey parasites in nature.

What then is the situation in Ceylon? We have found since 1963 that there are 5 species in our monkeys, two similar to the human *P.vivax* and belonging to the species *P.cynomolgi* (but a different subspecies) one in the toque monkey and the other in the grey langur, one species with a quartan periodicity like the human *P.malariae* (called *P.shortti*) one similar to the human *P.ovale* (called *P.simiovale*) and one like *P.falciparum* in its general behaviour but not producing cresentic gametocytes, called *P.fragile*. (Dissanaike, 1963, 1965; Dissanaike *et al* 1965 and 1965a). We have tried to transmit all these species by blood inoculation to human beings but have so far failed to establish infections. It may however be easier to do this by mosquito transmission. Unfortunately the vector has not yet been found for any of these parasites although experimentally the parasites have been passed through other species of *Anopheles* in London and thereby the liver stages demonstrated. We are nevertheless on the lookout for possible sporadic cases of simian infection in our colonists and blood from cases where we note a suspicious morphology, is inoculated into clean rhesus monkeys to see if the parasites will take in them, until now this has been the sure test for a simian origin of any such parasite occurring in man. Even this 'test' has recently been upset by the findings of Deane *et al.* (1966) who claim to have infected splenetomised squirrel monkeys experimentally with the human *P.vivax!*

THE LUNG FLUKES—Paragonimus

Lung flukes belonging to the genus *Paragonimus* are found in a variety of mammals which feed on fresh water crabs and crayfish which are the second intermediate hosts of these flukes. *P.westermani* is the only one of these flukes that develops normally in man, and is therefore a potential danger to man wherever it occurs. However, the infection in man is confined to places where the food habits make infection possible. Let us briefly consider the life cycle of this lung fluke. The adult worms are found in pairs in small cysts in the lungs generally near the parietal pleura, each fluke in the live state being thick and fleshy. The pair resembles a pair of coffee seeds when fixed. Eggs escape into the cysts, find their way to the bronchi and finally to the sputum where they are coughed out or may be swallowed. When these eggs reach water they continue to develop miracidia larvae within them which hatch out and find their way into

a fresh water snail that acts as the first intermediate host. The cercarial stages that finally develop in the soft tissue of the snail are now believed to reach the second intermediate host (crab) by the latter eating the snail. The definitive host then becomes infected by eating these crabs, containing the metacercaria larvae, which hatch out in the intestine bore their way into the petitoneal cavity remain in the abdominal wall for a short period and finally reach the lungs by penetrating through the diaphragm.

P.westermani in man is endemic in countries like Korea, Formosa, Japan, Central China and the Phillippines. The most important mode of infection in all these areas is obviously by eating raw or imperfectly cooked crabs. However, the accidental transfer of metacercariae through handling of crabs when preparing them for food is a possible method of infection as pointed out by Yokogawa (1952). He showed in Japan that most people stated that crabs were well cooked, boiled, fried or baked or prepared as soup. To prepare soup the shell and legs are removed while still alive and the bodies are crushed and chopped with a knife on a chopping block—they are strained through a bamboo basket with water, soya bean paste or sauce is added and the soup cooked for 10-20 minutes with vegetables or noodles. All this cooking will certainly kill the metacercaria. However, he found that during the preparation of the crab soup—the metacercariae cling to the chopping block, the knife, the bamboo basket and the hands of the cook and can be easily transferred to the other foods directly. He concluded, that infection in Japan came mostly from the preparation of crab soup and not by eating raw crabs.

Recently we found *Paragonimus westermani* to be quite a common parasite of the lungs of leopards and wild cats like the rusty spotted cat, the civet cat and the fishing cat, in the North Central and Southern provinces. (Dissanaike and Paramananthan 1962). Of 6 leopards that we examined 4 were infected, some with several hundreds of worms. We also searched for the metacercariae of these worms in fresh water crabs. The commonest fresh water crab in Ceylon is *Paratelphusa ceylonensis* which Fernando (1960) showed to be widely distributed in Ceylon. Of several hundred crabs examined we have so far found one positive crab in Nocchiyagama near the Wilpattu game sanctuary. It is well known that these crabs are eaten by the poorer classes, especially estate labourers as a source of animal protein and some even use preparations of these crabs for the treatment of cough (Fernando, 1960).

The most characteristic symptoms of paragonimiasis in man are cough and blood stained sputum. Clinically it is sometimes difficult to distinguish it from a case of pulmonary tuberculosis. Even by X-ray examination it is difficult to differentiate this disease from pulmonary tuberculosis. The presence of nodular ring shadows, which are said to be typical of paragonimiasis by tomography are not always seen. There is therefore every possibility that a few cases at least with cough and blood stained sputum may be due to *Paragonimus*, specially in the N.C.P. area.

HYDATID DISEASE

Hydatid disease is one of the more important zoonoses which can be acquired in the jungles as well as in the domestic environment. It is therefore a sylvatic as well as a domestic zoonosis. Hydatid cysts represent the larval stages of a minute tapeworm of dogs and other Canidae, called *Echinococcus granulosus* which inhabits the small intestine. The usual intermediate hosts are herbivorous animals which become infected with hydatid cysts by accidentally swallowing the eggs of this tapeworm. The eggs are found contaminating grass, water, the fur of dogs and other animals that pick them up from contaminated grass. Man acts as an accidental intermediate host.

A hydatid cyst is a unilocular cyst the wall of which is said to consist of three layers. The outermost layer however, which is called the pericyst is in fact the fibrous tissue adventitious layer contributed by the host. The other two layers which can easily be peeled off really belong to the parasite and are called the ectocyst and endocyst respectively. The former is a laminated hyaline structureless layer which is elastic and about 1 mm in thickness, and closely adherent to its inner surface is the germinal layer or endocyst. This is a nucleated layer from which the all important brood capsules arise. These brood capsules are about 1 mm in diameter and contain 20-40 inverted scolices of the future worms. In addition to these structures a large number of so called daughter cyst which are about the size of marbles, develop in cysts of animals which have a long life span, especially in man. These have the same structure as the mother cysts but have no pericyst. The definitive hosts become infected by eating the cyst-containing offal and thereby ingesting several proto-scoleces each of which develops to an adult worm.

When hydatid cysts develop in man they may grow to a great size sometimes as large as a football. They usually develop in the liver and less often in the lungs, brain, spleen and other organs. As space occupying bodies they can cause serious effects and by accidental rupture can give rise to anaphylactic shock.

What is the situation with regard to this parasite in Ceylon? Hydatid cysts have been reported from local animals since 1912 (Southwell, 1912, Seneviratna 1955, Dissanaike, 1957; 1958 and 1962, Paramananthan, 1961). The majority of cysts in local animals are in the lungs and the animals involved are cattle, goats and buffaloes. A high incidence of hydatid cysts has also been observed in sheep and goats imported from India. The adult worm has been reported from dogs in Kandy, and Colombo on several occasions (Seneviratna, 1955, Dissanaike, 1957 and 1961, Dissanaike and Paramananthan, 1961). It was obvious then that dogs in Ceylon specially in Colombo were becoming infected from one or other of the following sources—

(*a*) Animals imported from India,

(*b*) Local cattle, buffaloes and goats.

The imported animals come from South India where infection is common in man (Reddy *et al* 1959). The second source of infection of dogs are animals brought to the city mainly from the Northern and North Central Provinces, where it is common to see cattle grazing in numbers bordering the jungles. The source of infection of these animals was obviously a jungle carnivore, and the jackal was shown to be the definitive host in this jungle cycle (Dissanaike and Paramananthan, 1960). Later it was shown that the sambhur was one of the intermediate hosts in the sylvatic cycle (Fig. 2) (Dissanaike and Paramananthan, 1962). All these findings strongly suggested that hydatid cysts could and should occur in the local indigenous population and we pointed this out on several occasions. The first case in a local person was reported in 1963 by the late Professor Karunaratne and Thambar in a Sinhalese male aged 25 years who was admitted to the Eye Hospital with a marked proptosis of the left eye, which was enucleated. A tense cyst of the orbit containing several scolices was removed. All other cases of hydatids in man in Ceylon of which there had been 15 reported, have been in foreigners mainly Indian

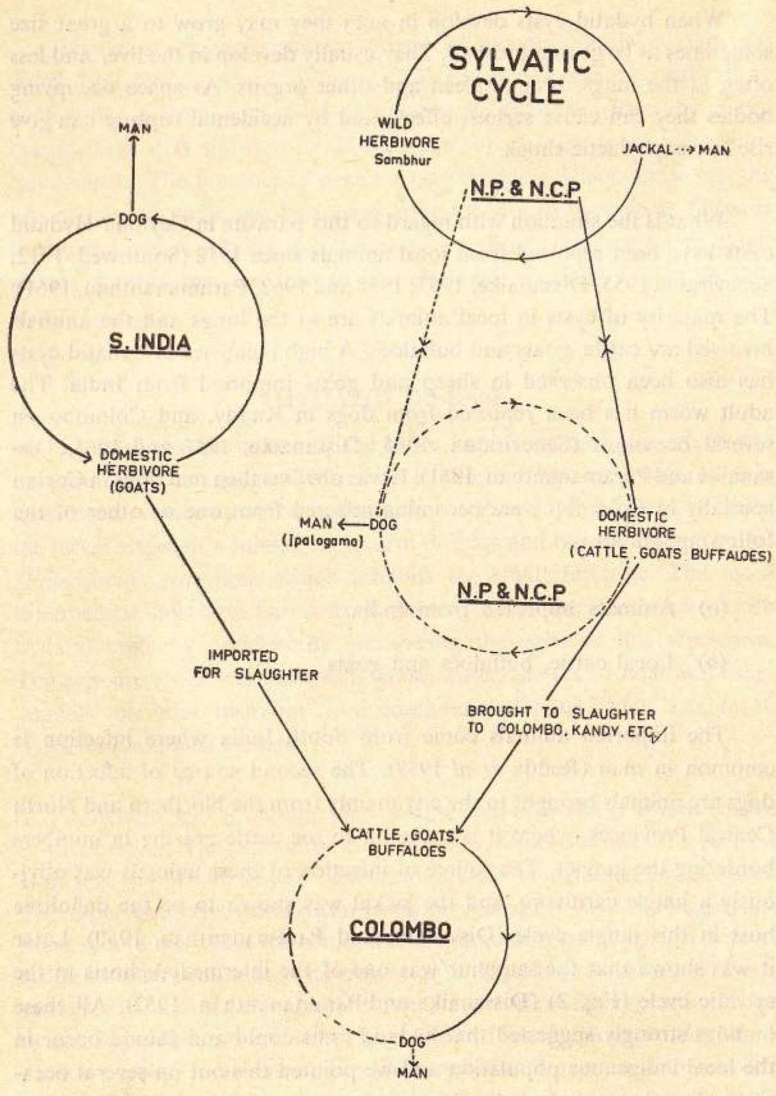


Fig. 2

Tamils (Table 3). In other countries where hydatid cysts are common, cysts of the orbit are said to represent only 1% of the total number of the cysts. I was certain that the incidence of hydatid cysts in local people is much higher than it appears to be and that cases especially from the

TABLE III

HUMAN HYDATIDS RECORDED IN CEYLON

Case No.	*Year*	*Nationality*	*Age*	*Sex*	*Site*
1	1887	Malabar estate labourer.	—	—	Right retroperitoneal.
2	1905	Boer prisoner of war.	—	—	—
3	1949	Indian Tamil	35	F	Right kidney.
4	1952	Indian Tamil	—	M	Liver.
5	1952 (A.P.)	South Indian	35	F	Lung and liver.
6	1954 (J.M.S.A.)	Indian Tamil	32	F	Spleen and omentum.
7	1957 (M.M.)	Indian Tamil	30	M	Liver.
8	1957 (M.K.A.)	Indian Tamil	27	F	Liver.
9	1958 (P.K.)	Indian Tamil	42	M	Liver; pelvic cyst.
10	1961 (V)	Indian Tamil	49	M	Right hypochondrium. extra peritoneal cysts? kidney.
11	1961 (P.M.)	Indian Tamil	45	M	Liver, omentum causing intestinal obstruction? recurr.
12	1962 (A)	Indian Tamil	30	M	Spleen, liver (caseated).
13	1963 (S)	Indian Tamil	23	M	Brain.
*14	1963 (P.S.)	Sinhalese	30	M	Orbit.
15	1963 (V)	Indian Tamil	55	F	Liver.
16	1965 (A)	Indian Tamil	35	F	Liver.
*17	1967	Sinhalese	12	M	Lung.

Northern and North Central Provinces have been undetected in the past. I was therefore glad to hear a few days back of the second case of hydatids from a Sinhalese patient. The cyst was in the right middle lobe of the lung of a 12 year old boy from Kandana. (Rasaratnam, 1967).

I have discussed only a few of the parasites of animals in Ceylon that can infect man in various ways, they come from three separate environments, domestic, intermediate and sylvatic. (Fig. 3). Most of them, as

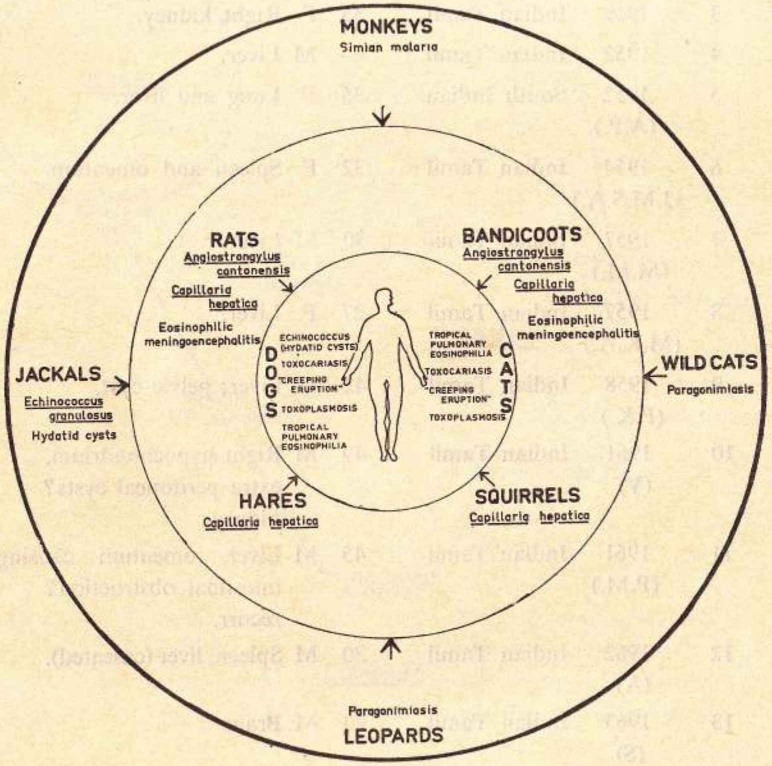


Fig. 3

I have pointed out, do not cause any dramatic disease or death, they give rise on the other hand to obscure signs and symptoms, often of a chronic nature. A few of them are perhaps only of academic interest, nevertheless an awareness of them is necessary. I would urge the clinicians to be on the lookout for some of these infections when the clinical picture does not fit in with the normal patterns, but suggests some parasitic infection often

a helminthic one from an animal source. A confirmation of such a diagnosis is often difficult I admit, unless the offending organism is found or isolated.

I would now like to end with a few more lines from Pope once again taken out of their context from his same poem on the Essay on Man, which more or less summarises what I have been trying to say during the past hour—

"Thus then to man the voice of Nature spake—
Go, from the creatures thy instruction take".

References

ABDUL CADER, M. H. M., THARUMARAJAH, K. and RAJENDRAN, K. (1966), Filarial infection in domestic cats in Ceylon. *Bull.Indian Soc.commun.Dis,.* **3,** 155-158.

ALICATA, J. E. (1965). Biology and distribution of the Rat Lungworm, *Angiostrongylus cantonensis*, and its relationship to Eosinophilic Meningitis and other neurological disorders of man and animals.
In *Advances in Parasitology*, **3,** Edited by Ben Dawes p. 223-248. Academic Press, London and N.York.

ALICATA, J. E. (1966). The presence of *Angiostrongylus cantonensis* in islands of the Indian ocean and probable role of the Giant African snail, *Achatina fulica*, in dispersal of the parasite to the Pacific islands. *Can.J.Zool.*, **44,** 1041-1049.

ASHTON, N. (1960). Larval granulomatosis of the retina due to *Toxocara. Br. J.Ophthal.*, **44,** 129-148.

ATTYGALLE, D. AND DISSANAIKE, A. S. (1967). Unpublished data.

BALFOUR, A. (1925). Letter to the Editor. *J.Parasit.*, **12,** 115.

BEAUTYMAN, W. AND WOOLZF, A. L. (1951). An *Ascaris* larva in the brain in association with acute Anterior Poliomyelitis. *J.Path.Bact.*, **63,** 635-647.

BEAVER, P. C., SNYDER, C. H., CARRERA, G. M., DENT, J. H. AND LAFFERTY, J. W. (1952). Chronic Eosinophilia due to Visceral Larva migrans. *Pediatrics, N.Y.* **9,** 7-19.

BECROFT, D. M. O. (1964). Infection by the dog roundworm *Toxocara canis* and fatal myocarditis. *N.Z.med.J.*, **63,** 729-732.

BRAIN, LORD AND ALLAN, B. (1964). Encephalitis due to infection with *Toxocara canis.Lancet*, **1,** 1355-1357.

BRAY, R. S. (1963). Malaria infections in primates and their importance to man. *Ergebn, Mikrobiol.Immun.Forschexp.Ther.* **36,** 168-213.

BUCKLEY, J. J. C. (1958). Tropical Pulmonary Eosinophilia in relation to filarial infection (*Wuchereria* sp.) of animals. *Trans. R.Soc.trop.Med.Hyg.*, **52,** 335-336.

BUCKLEY, J. J. C. (1960). On *Brugia* gen. nov. for *Wuchereria* spp. of the '*malayi*' group. i.e. *W.malayi* (Brug, 1927) *W.pahangi* Buckley and Edeson, 1956, and *W. patei*, Buckley, Nelson and Heisch 1958. *Ann.trop.Med.Parasit.*, **54,** 75-77.

CAMERON, G. R. (1961). Personal communication.

CAMERON, T. W. M. (1962). Helminths of Animals transmissible to man. *Am. J.med.Sci.*, **243**, 354-381.

CHASE, S. (1957). *The Proper Study of Mankind.* Phoenix House Ltd. London.

CHIN, W., CONTACOS, P. G., COATNEY, G. R. AND KIMBALL, H. R. (1965). A naturally acquired quotidian type malaria in man transferable to monkeys. *Science, N.Y.* **149**, (3686) 865.

COATNEY, G. R., CHIN, W., CONTACOS, P. C. AND KING, H. K. (1966). *Plasmodium inui*, a quartan-type malaria parasite of old world monkeys transmissible to man. *J.Parasit.*, **52**, 660-663.

COCHRANE, J. C., SAGORIN, L. AND WILCOCKS, M. G. (1957). *Capillaria hepatica* infection in man. A syndrome of extreme eosinophilia, hepatomegaly and hyperglobulinaemia. *S.Afr.med.J.*, **31**, 751-755, (*Trop.Dis.Bull.*, Dec. 1957).

CONTACOS, P. G., LUNN, J. S., COATNEY, G. R., KITPATRICK, J. W. AND JONES, F. E. (1963). Quartan-type malaria parasite of New world monkeys transmissible to man. *ScienceN.Y.*, **142**, 676.

DANARAJ, T. (1966). The aetiology of Eosinophilic lung (Tropical Eosinophilia) *Proc.First International Congress of Parasitology*, Rome, 21-26 Sept., 1964. Edited by Corradetti. Pergamon Press.

DEANE, L. M., DEANE, M. P. AND FERREIRA NETO, J. (1966). A naturally acquired human infection by *Plasmodium simium* of Howler monkeys. *Trans.R. Soc.trop.Med.Hyg.*, **60**, 563-564.

DEANE, L. M., FERREIRA NETO, J. AND SILVEIRA, I. P. S. (1966a). Experimental infection of a splenectomised squirrel monkey, *Saimiri sciureus* with *Plasmodium vivax.Trans.R.Soc.trop.Med.Hyg.*, **60**, 811-812.

DISSANAIKE, A. S. (1957). Some preliminary observations on Echinococcus infection in local Cattle and dogs. *Ceylon med.J.*, **4**, 69-75.

DISSANAIKE, A. S. (1958). On hydatid infection in a Ceylon toque monkey, *Macaca sinica.Ceylon vet.J.*, **6**, 33-35.

DISSANAIKE, A. S. (1961). On some helminths of dogs in Colombo and their bearing on human infections, with a description of a new trematode *Heterophyopsis yehi* sp. nov. (Heterophyidae). *Ceylon J.med.Sci.*, **10**, 1-12.

DISSANAIKE, A. S. (1962). Observations on Echinococcus infection in Ceylon. *Proc. FirstRegional Symposium on Scientfic Knowledge of Tropical Parasites*, Singapore, 1962. p. 223-240.

DISSANAIKE, A. S. (1963). *Plasmodium* infection in Ceylon Monkeys. *Trans.R Soc.trop.Med.Hyg.*, **57**, 488-489.

DISSANAIKE, A. S. (1965). Simian Malaria parasites of Ceylon. *Bull.World Hlth. Org.*, **32**, 593-597.

DISSANAIKE, A. S. AND PARAMANANTHAN, D. C. (1960). On the occurrence of *Echinococcus granulosus* (Batsch, 1786) in a Ceylon jackal. *Ceylon vet.J.*, **8**, 82-86.

DISSANAIKE, A. S. AND PARAMANANTHAN, D. C. (1961). On *Brugia* (*Brugiella subgen.* nov.) *buckleyi* n.sp., from the heart and blood vessels of the Ceylon hare. *J.Helminth.*, **35**, 209-220.

DISSANAIKE, A. S. AND PARAMANANTHAN, D. C. (1961a). On *Capillaria hepatica* infection in the Ceylon bandicoot (*Bandicota malabarica*). *Ceylon vet.J.* **9**, 9-11.

DISSANAIKE, A. S. AND PARAMANANTHAN, D. C. (1962). On the occurrence and significance of Hydatid cysts in the Ceylon sambhur *Rusa unicolor unicolor. Ceylon J.med.Sci.*, **11**, 1-7.

DISSANAIKE, A. S. AND PARAMANANTHAN, D. C. (1962a). *Paragonimus* infection in wild carnivores in Ceylon. *Ceylon J.med.Sci.*, **11**, 29-45.

DISSANAIKE, A. S. NELSON, P. AND GARNHAM, P. C. C. (1965). Two new malaria parasites, *Plasmodium cynomolgi ceylonensis* sub sp. nov., and *Plasmodium fragile* sp. nov. from monkeys in Ceylon. *Ceylon J.med.Sci.*, **14**, 1-9.

DISSANAIKE, A. S., NELSON, P. AND GARNHAM, P. C. C. (1965a). *Plasmodium simiovale* sp. nov., a new Simian Malaria Parasite from Ceylon. *Ceylon J.med.Sci.* **14**, 27-32.

DUGUID, I. M. (1961). Feature of Ocular Infection of *Toxocara. Br.J.Ophthal.*, **45**, 789-796.

EDESON, J. F. B., RAMACHANDRAN, C. P., ZAINI, M. A., NAIR, S. AND KERSHAW, W. (1962). The transmission of Malayan Filariasis to rodents. *Trans.R.Soc. trop.Med.Hyg.*, **56**, 269.

EYLES, D. E., COATNEY, G. R. AND GETZ, M. E. (1960). Vivax-type malaria parasites of macaques transmissible to man. *Science N. Y.*, **131**, 1812-1813.

FERNANDO, P. B. AND BALASINGHAM, S. (1943). Acute ascariasis in children. *Indian J. Pediat.*, **10**, 149-173.

FERNANDO, C. H. (1960). The Ceylonese Fresh water crabs (Potamonidae). *Ceylon J. Sci. biol. Sci.*, **3**, 191-222.

FRANKISH, J. D. (1965). Toxocariasis: Report of one surviving case. *N.Z. med. J.*, **64**, 212-214.

GARNHAM, P. C. C. (1958). Zoonoses or infections common to man and animals. *J. trop. Med. Hyg.*, **61**, 92-94.

HARRIS, W. (1961). Pseudoglioma due to larval choroido-retinal granulomatosis. *Br. J. Ophthal.*, **45**, 144-146.

HEISCH, R. B. (1956). Zoonoses as a study in Ecology. *Br.med.J.*, **2**, 669-673.

HUTCHISON, W. M. (1965). Experimental transmission of *Toxoplasma gondii Nature, Lond.*, No. **4987**, 961-962.

HUTCHISON, W. M. (1967). The nematode transmission of *Toxoplasma gondii Trans.R.Soc.trop.Med.Hyg.*, **60**, 80-89.

INNES, J. R. M. AND SHOHO, C. (1952). Nematodes, Nervous disease, and Neurotropic virus infection-observations in animal pathology of probable significance in medical neurology. *Br.med.J.*, **2**, 366-368.

IRVINE, W. C. AND IRVINE, A. R. (1959). Nematode endophthalmitis: Toxocariasis. *Br.J.Ophthal.*, **47**, 185-191.

JAYEWARDENE, L. G. (1962). On two filarial parasites from dogs in Ceylon, *Brugia ceylonensis* n.sp. and *Dipetalonema* sp. inq. *J. Helminth.*, **36**, 269-280.

KARUNARATNE, W. A. E. AND THAMBER, S. V. (1963). Hydatid disease with special reference to the orbit. *Trans.ophthal.Soc.Ceylon*, **6**, 16-20.

KULASIRI, C. DE S. (1962). The isolation of *Toxoplasma gondii* Nicolle and Manceaux from some Ceylon rodents. *Ceylon J.med.Sci.*, **11**, 9-14.

KULASIRI, C. DE S. (1967). Personal communication.

KULASIRI, C. DE S., THIRUNAVAKARASU, S. AND WIJEWATHIE, U. H. M. (1965). *Toxoplasma gondii* Nicolle and Manceaux in dogs and cats in Ceylon. *Ceylon J.med.Sci.*, **14**, 33-35.

LOOSS, A. (1911). The anatomy and life history of *Agchylostoma duodenale* Dub. Part II. The development in the free state. *Rec.Egypt.Govt.Sch.Med.* **4**, 163-613. (cited by Beaver, P.C., *Expl. Parasit.*, **5**, 587-621 (1956).

MACKERRAS, M. J. AND SANDARS, D. F. (1955). The Life history of the rat Lungworm, *Angiostrongylus cantonensis* (Chen) (Nematoda: Metastrongylidae). *Australian J. Zool.*, **3**, 1-21.

McCarthur, W. P. (1924). A case of infestation of the human liver with *Hepaticola hepatica* (Bancroft, 1893) Hall, 1916. *Proc.roy.Soc.Med.*, **17**, 83-84.

Lubinsky, G. (1956). On the probable presence of parasitic liver cirrhosis in Canada. *Can.J.comp.Med.*, **20**, 457-465.

Mochizuki, H., Tomimura, T. and Oka, T. (1954). Cerebrospinal nematodiasis as a provoking factor in Japanese B encephalitis—an experimental approach. *J.infect. Dis.*, **95**, 260-266.

Nelson, G. S. (1960). Schistosome infections as zoonoses in Africa. *Trans.R. Soc.trop.Med.Hyg.*, **54**, 301-316.

Nelson, G. S. (1965). Filarial infections as Zoonoses. *J.Helminth.*, **39**, 229-250.

Otto, G. F., Berthrong, M., Appleby, R., Rawlins, J. and Wilbur, O. (1954). Eosinophilia and Hepatomegaly due to *Capillaria hepatica* infection. *Bull. Johns Hopkins Hosp.*, **94**, 319-336.

Paramananthan, D. C. (1961). Some observations on brood capsules of hydatid cysts from local animals. *Ceylon J.med.Sci.*, **10**, 57-59.

Rasaratnam, R. (1967). Personal communication.

Ratnavale, W. D. and Dissanaike, A. S. (1964). On the Second case of human infection with *Dirofilaria* (*Nochtiella*) *repens* from Ceylon. *J.Helminth.*, **38**, 287-290.

Reddy, D. J., Gopalakrishniah Gupta, K. and Venkiah, K. R. (1959). Hydatid disease in India with special reference to its incidence in Guntur. *Arch. Internac. Hidatid.*, **17**, 61-75.

Rosen, L. (1967). Eosinophilic Meningitis. *ICTM Newsletter*, Sept. 1967.

Seneviratna, P. (1955). A checklist of the helminths in the Department of Veterinary Pathology, University of Ceylon, Peradeniya. *Ceylon vet.J.*, **3**, 32-37.

Seneviratna, P. (1955a). Observations on Helminth infection in cats in Kandy District, Ceylon. *ibid.*, **3**, 54-58.

Southwell, T. (1912). A description of ten new species of Cestode parasites from marine fishes of Ceylon, with notes on other cestodes from the same region. *Rep.Ceylon Mar.biol.Lab.*, **1**, 259-278.

Webb, J. K. G. (1960). Aetiology of Tropical Eosinophilia, *Indian J.Child Hlth.*, **9**, 227-230.

World Health Organization (1951). Joint WHO/FAO Expert Committee on Zoonoses. 1st Report. *Wld.Hlth.Org.tech.Rep. Series.*, **40**, (1951).

World Health Organization (1959). Joint WHO/FAO Expert Committee on Zoonoses. 2nd Report. *Wld.Hlth.Org.tech.Rep. Series.*, **169**, (1959).

Wijetilleke, S. E., Attygalle, D. and Dissanaike, A. S. (1962). A case of human infection with *Dirofilaria* (*Nochtiella*) sp., probably repens, from Ceylon. *Ceylon J.med.Sci.*, **11**, 51-54.

Wilder, H. C. (1950). Nematode endophthalmitis. *Trans.Am.Acad.Ophthal. Oto.-lar.* **55**, 99-

Woodruff, A. W. and Thacker, C. K. (1964). Infection with animal helminths. *Br.med.J.*, **1**, 1001-1005.

Woodruff, A. W., Bisseru, B. and Bowe, J. C. (1966). Infection with animal helminths as a factor in causing poliomyelitis and epilepsy. *Br.med.J.*, **1**, 1576-1579.

Yokogawa, M. (1965). Paragonimus and Paragonimiasis. in *Advances in Parasitology*, **3**, Edited by Ben Dawes. p. 99-158. Academic Press. London and N. York.

SECTION B—AGRICULTURE AND FORESTRY

Presidential Address

ECONOMICS OF PLANT DISEASE CONTROL

by

O. S. Peries

The title of my address needs some clarification, I freely admit that it was not chosen because I am qualified to speak on it—I am no economist; in fact, my friends have told me, in no uncertain manner, that I will be committing economic suicide at the end of this month. That makes me even less qualified to speak on economics. However, I think it was Disraeli (1845) who wrote, more than a century ago: "to be conscious that you are ignorant is a great step to knowledge", and I find that a comforting thought in trying to handle a subject about which, not only I but the whole world is largely ignorant—so I am in good company.

My intention here is merely to discuss plant disease losses in general, outlining the methods of control, and to give a few examples of methods of reducing control costs—the examples cited will be right here from Ceylon. I do this in the hope that further interest may be aroused by this, in the accurate assessment of damage caused by plant diseases, so that control measures may be applied more critically than they have been done in the past.

Let us consider, what is a plant disease? Man, animals and insects are dependant on green plants directly or indirectly for food. Some plants, particularly, fungi have no chlorophyll and, like animals, depend on other plants for food—this is parasitism, and the parasite often interferes with the functioning of the affected plant, and disease is the result. From man's point of view this is bad, although the parasite does the same thing we do, i.e. lives on the products of the green plant. However, the parasite both lodges and boards with its host, and eats at the first table besides. We get what is left over, which is sometimes a very small portion.

Diseases and pests are not always to blame, man is often the villian of the piece. Take the case of a tea bush for example, leaves are removed as harvest, but if too many leaves are removed, as by continuous over-plucking, death would result. This would be called mismanagement. However, if the continuous stripping is done by a fungus or insect, the death would be attributed to a disease or pest attack. Thus we speak of fungus, bacterial and virus diseases, insect pest attacks and man's mis-management, but as far as the plant is concerned, the consequences are the same. Today I will confine my remarks mainly to diseases and in passing to pests, although the damage caused by mismanagement may be just as important.

Now let us take a brief look at the grave economic impact that plant diseases can have on human life. The classical example here, which is referred to in every text book of plant pathology, is Ceylon's own experience with coffee rust, caused by *Hemileia vastatrix*. This disease changed the history and social life of nations. Ceylon was for a long time the greatest coffee-producing country in the world. The average annual production was about 450 lbs. of clean coffee per acre. England was one of our best customers, and, in those days, consumed about equal amounts of coffee and tea. The English coffee house was an established and much-loved social institution. Then the leaf rust struck Ceylon, and in a few years, production dropped to 200 lbs. per acre, later to much less. Losses to our country were in the region of £ 2 million per year, and became worse. The British navy was called upon to help in one of the most remarkable migrations in modern times. The coffee planters had failed. Other planters came in and started growing tea to replace coffee. Now Englishmen drink about eight times more tea than coffee—this was the aftermath of one disease (Wellman, 1961).

Let us consider one more; the plant disease that brought about the most tragic results, is perhaps the potato blight, which caused the Irish famine in the mid-nineteenth century. The basic reason for this was that the impoverished population of Ireland at that time depended almost entirely on potatoes for food, so that two years of severe blight, in 1845 and 1846, which practically destroyed their whole crop, led to mass starvation. Ireland lost almost a third of its population between 1845 and 1860, as a direct result of late blight. A million died of starvation and 1½ millions migrated—the social and economic implications of this disease are apparent up to date. The strained relations between Britain and Ireland to this

day were conceived at the time of the Irish blight, because of Britain's neglect of the starving Irish people, and the mass migration from Ireland has resulted in half the New York policemen today being of Irish descent (Large, 1940).

The total economic importance of a plant disease must be measured not only by the actual damage done, but also by the costs of preventive and control measures and by the limitations that diseases sometimes impose on the kinds and varieties of crop plants that can be grown in some places. A striking example of this is the replacement of the desirable banana variety Gros Michel, which is extremely susceptible to Panama disease, by the resistant variety Lacatan. In addition to being less palatable, Lacatan although resistant to Panama disease, is highly susceptible to leaf spot, against which expensive control measures have been adopted, increasing cost of production by 15 to 20 percent. However, it is the lesser of the two evils.

Unfortunately it is almost impossible to calculate accurately the world-wide tax that diseases levy on economic plants. Data are not available for many countries and they are woefully inadequate for most. Estimates when available cannot be claimed to be much more than well informed guesses. The literature on the subject is even misleading. Non-statistical terms are often used in Annual Reports e.g. a disease may be described as "less severe than the previous year", while the previous year's Report may not even mention it! Every scientific paper I have read, in which there is a reference to losses caused by plant diseases and pests, points out that the estimation of losses is difficult, and no country apparently has accurate records on all its important diseases.

I know that figures have frequently been quoted in text-books and elsewhere to show the monetary loss caused by this or that disease, but these figures have rarely been based on firm foundations and usually little or no account has been taken of the other interacting factors involved. I have often seen income and expenditure accounts that have been drawn up, showing the normal value of the crop yield in the absence of a particular disease, the cost of treatment and the net gain derived from applying the treatment. But where this is done for several diseases on the same crop, simple addition shows that often the total net gain far exceeds the normal total value of the crop (Moore, 1949).

Let me now give the figures from one authenticated case of the factual losses caused by a plant disease, where the above absurd statistical errors are absent. In 1935 there was a severe attack of stem rust of wheat in the United States, where 100 million bushels of wheat, worth upwards of £ 50 million, were destroyed. The actual production of wheat, finally was 98 million bushels, but much of this was light weight and there was a reduction of price as quality dropped. The consequences to farmers were tragic. They lost 5 to 20 bushels per acre over their planted acreage, they lost heavily in price per bushel on what they harvested and they lost money in many cases on harvesting something that could not be sold. One farmer who grew 500 acres, showed from his cost accounts that he would have saved 5,000 dollars if he had ploughed in his wheat fields instead of harvesting them. The consequences to business were severe. The railways lost heavily as they had less goods to transport, wholesale firms that had booked business could execute only 50% of their business. Farm machinery dealers had to close down their business as there were no sales. It was a national calamity (Stackman & Harrar, 1957).

Now let us look at the *estimated* losses caused by plant diseases in different countries. In the United States, the average annual loss from plant diseases is estimated to be 3 billion dollars (Wood, 1953). In the U.K. plant diseases are estimated to cause about 10-15% crop losses over-all. Therefore, on the wheat crop alone it can lose £ 3 million, and on potatoes, in a bad year, another £ 3 million (Ordish, 1952). In Canada losses caused by stem rust of wheat is computed at £ 35 million and smut £ 12 million (Conners, 1954). In Australia it is generally believed that annual losses from crop diseases are of the order of 10%, say in the region of £ 5 million from stem rust alone (Magee, 1954). India loses between 10 and 15% of her crops annually to plant diseases (Vasudeva, 1954), but Sir John Russel (1951) says that the figure for India should be higher than this, at least 20 per cent. Coming home to Ceylon, Fernando (1967) has made a conservative estimate that losses of paddy due to pest attacks, other than storage pests, is between 10 and 20% of the potential harvest. In financial terms this is approximately Rs. 175 million, or wasted human effort in cultivating about 375,000 acres, without any return whatsoever but merely to feed pests—this is the area of "untaken harvest" in George Ordish's (1952) terminology, in other words, the crop area lost. Abeygunawardena (1967) estimates that 5-10% of our paddy crop is lost through disease, this represents about 150,000 acres of "untaken harvest" resulting in a monetary loss of about Rs. 72 million. If we take the total losses caused by plant pests and diseases all over the world, the area of "untaken harvest" would represent the total cultivated area of the U.S.A. (Watts-Padwick, 1954).

We have now considered the economic effects of the incidence of pests. Let us now consider the methods of control of pests and diseases in broad outline. Our battle is against (1) insects and related animals (2) molluscs and worms (3) fungi and bacteria (4) viruses (5) higher animals, and (6) weeds. The weapons we have for the battle are: (1) mechanical (2) biological and (3) chemical methods of control. Let us consider each of these in turn:

Mechanical Methods

These involve ploughing, harrowing, rolling and burning to destroy pests or disease popagules, devising rotations to avoid them, adopting special times of sowing so as to by-pass periods favourable for pest and disease attacks or in the ultimate case—just not growing a particular crop, when control measure are completely uneconomical.

The rotation of crops has a profound effect on pests, and diseases, especially certain fungal diseases. The "take-all" disease of wheat is largely avoided by the adoption of suitable rotations and cultivation.

One of the most important devices to be considered here is quarantine—or the prevention of the introduction of diseases into countries by legislation. Certain diseases have the potential to annihilate a crop if it gets into a country. An example that comes readily to mind is the case of South American leaf blight of *Hevea*. If the causal organism, the fungus *Dothidella ulei* is introduced into the South-East Asian countries, where rubber is grown, say Ceylon, it could virtually knock out the crop. The high-yielding clones, grown in our part of the world, are extremely susceptible to the disease, and present plantations would be so badly damaged as to necessitate replanting to resistant but low yielding types. The direct economic effect of this would be the sudden death of the natural rubber industry. Therefore, rigid quarantine measures are adopted in Ceylon, and other rubber growing countries, in order to prevent the accidental introduction of this dread disease into our country and others producing natural rubber.

You would notice that these mechanical methods of plant disease prevention and control generally cost little or nothing, and are therefore economically attractive.

Biological Control

Basically, biological control involves the exploitation of the phenomenon of hyperparasitism. This means the use of one bacterium, fungus or insect to control another—a parasite. Biological control also refers to the adoption of a purely biological, as opposed to a mechanical or chemical, method of control, e.g. breaking the life cycle of a fungus by the removal of an alternative host, or the use of a crop variety that is immune or resistant to a pest or disease.

The examples of biological control by the introduction of predators are legion, the first modern success being the control of the cottony cushion scale in California by the introduction of the Australian ladybird, *Novius cardinalis*, as far back as 1900. Another famous case, which is better documented is the control of the coconut moth in Fiji by a Tachnid fly from Malaya, the total expenditure on research in this case was only some £ 22,000 but it resulted in an annual saving of £ 250,000. Coming to Ceylon for an example we have the very successful control of the Tea Tortrix Caterpillar by the parasite *Macrocentrus homone* introduced in 1935 and 1936. Right now Dr. Dantanarayana (1967) of the Tea Research Institute is studying the fungus *Beauveria bassiana*, which is pathogenic to the shot-hole borer, for possibilities of controlling the latter biologically. The biological control of weeds is also possible, and vast areas of land in Australia and South Africa have been cleared of prickly pear by the introduction of its insect pests. You can well imagine the value to Ceylon of insects that would chew up Salvinia or *Eupatorium*, without harming any crop plant.

An example of changing the crop variety to avoid disease has already been given, when I referred to the replacement of the banana variety Gros Michel by the less desirable but Panama Disease resistant variety Lacatan in Jamaica. The next logical step from this is breeding for disease resistance. Planned breeding can produce varieties of crop plants which are desirable from the point of view of high quality produce as well as disease resistance. From the host of examples of glamorous successes in this sphere, like potatoes immune to wart disease and wheat resistant to rust, I like to single out just one little known case for you here. Cucumber

blotch (*Cercospora melonis, Cooke*), which practically wiped out the crop in London some years ago, ceased to have any significance after the introduction of the variety Butcher's Disease Resister, which was derived from two unaffected plants in a crop, otherwise destroyed by the disease (Moore, 1949). Therefore, Plant Breeders, in addition to being able to transfer pollen from plant A to B, should also have keen eyesight, and be generally slick, because one ounce of detection may be worth a ton of cross-fertilization. I point this out merely to show that there is still a percentage in good old fashioned selection in most crops.

Biological control is undoubtedly the cheapest form of pest and disease control, it costs the grower almost nothing and the national expenditure on research is negligible. However, such methods have their limitations; they cannot always be found, and once found they may lose their efficacy, as the pathogens may vary from time to time. Therefore, however desirable or attractive biological control methods may be, due to their non-availability, we have to resort to other methods of control, which brings us to:

Chemical Control

The vast majority of pests and diseases all over the world are controlled by the use of chemicals. These are too well known for me to digress into a discussion on them. We are here interested in the economics of their use. The cost of control measures can be quite high. The capital investment in machinery, the cost of chemicals and labour in applying them, transport and storage facilities, all add up. Ther elative costs of spraying or dusting are high, as these operations must be repeated several times e.g. apples in the U.K. are sprayed about 10 times during the year with different materials for various reasons, potatoes are sprayed between 3-10 times when late blight is bad, and sometimes 15 to 20 times in certain Andean regions of South America where the growing season is long and weather favours blight development. Tea in Ceylon is sprayed up to 30 times for Blister Blight control and rubber dusted about 12 rounds for *Oidium* leaf disease control.

The total cost of chemical control has been computed to be about ½ to 5 per cent of the value of the crop in low value crops, 10 per cent in medium value and up to 20 per cent in high value crops. This cost differential depends on the fact that in the case of crops with a relatively low value per unit area, the application of advanced techniques of plant protection normally comes about as a result of encouragement or pressure from outside, whereas with crops of high value per unit area, it is the producer who applies the pressure and is impatient for fresh knowledge. It therefore does not follow that the producer, the plant pathologist and the economist see eye to eye on the importance of disease control. To minimise expenditure on disease control, intensive studies must be carried out on the pathogen, the host and meteorological conditions favouring the disease. Let me give you just two examples from our own country of how disease control costs on two different crops have been reduced by careful studies on the above lines.

I will speak about *Phytophthora* leaf disease control on rubber first, as I know the case from the inside, having been personally involved with the studies. It is only in the last 5 years or so that the control of *Phytophthora* leaf disease has been viewed with any degree of rationality in this country. Up to that time people were running around making wild statements about *Phytophthora* causing 50% drop in yield and spelling the doom of the crop in Ceylon. Then we decided to take a closer look at the problem —we concluded at that stage that there were three aspects of the problem, which were worthy of careful investigation viz.: (1) the severity of the disease in Ceylon (2) the economic significance of the disease—how much damage was it doing? (3) What control methods could be adopted and how effective were those methods? Then we analysed each of these facets of the problem.

First, the severity of the disease—when a careful survey of the records available from 1926 was made, it indicated clearly that there was a certain pattern in the incidence of this disease, "severe" attacks occurred about once in 6 years, in addition there were local epidemics in certain areas just as frequently, but, every one year in four the disease could hardly be found. Our studies from 1962 onwards have amply justified these conclusions. The indications were that *Phytophthora* leaf disease assumed epidemic proportions only when the weather was wet, dull and overcast for relatively long periods during the South-West Monsoon season. Epidemiological research (Peries and Samaraweera, 1964, 1965, 1966, 1967) and studies on the biology of the causal fungus (Peries and Fernando, 1966) enabled us to use the above observations to the best advantage, and formulate a tentative method of forecasting the incidence of leaf fall epidemics (Peries, 1965).

Second, the effect on yield—when I just said that "severe" attacks of *Phytophthora* occurred every sixth year, I meant that word severe to be placed within inverted commas. The attack was alleged, claimed, or otherwise purported to be severe. However, when we laboriously counted the leaves on a number of trees and worked out a formula by which we could express the number of diseased leaves on the ground as a proportion of the number of leaves per acre on healthy trees, we found that *Phytophthora* normally causes only about 10-25% leaf fall, and 50-75% in very severe cases, which were rare. This is in marked contrast to the position in South India, where *Phytophthora* causes complete and general defoliation of all their rubber every year. This does not happen in Ceylon. So we carried out experiments to assess the effect of various levels of defoliation on the yield of latex, by counting the leaves on young trees and defoliating them to various levels—and surprisingly, we found that more than 75% of the leaves of young rubber trees had to be picked off before this caused any significant difference to the yield of the tree. I admit that the position may be different in mature trees, but it may be accepted that a high degree of defoliation must occur before it would have a significant effect on yield. The work of Grainger in England, who showed that when a plant is defoliated by a disease or by mechanical means, the efficiency of the remaining leaves increases so as to compensate for this loss, supports our contention. Therefore, we concluded that the extent of leaf fall caused by the disease generally in Ceylon, would not have a significant effect on yields.

Finally, the third aspect—the efficacy of the control measures available. From experience in other countries, we know that spraying is better than dusting for *Phytophthora* leaf disease control, but we tested a number of hand-portable spraying machines, some designed with our help and advice, but none of them came up to the standards required for the job. So we had to fall back on dusting, as aerial spraying too was not feasible. Then we tested the sticking properties of all the copper dusts available in the market, and the result was a sad tale, all the dusts were washed off rubber leaves at the nearest touch of rain, in fact ½ inch of rain washed off 99% of all brands of copper dusts retained on the leaf after dusting. Anybody who has seen the South-West Monsoon rains in the rubber-growing districts of Ceylon will laugh at ½ an inch of rain. So actually the copper was washed off when it was most needed (Peries, 1966).

We concluded from our studies that: (1) Severe attacks of *Phytophthora* leaf fall occur only once in about six years in Ceylon. (2) Even when *Phytophthora* leaf fall is described as "severe" the leaf fall which generally occurs is not expected to lead to a drop in yields, and (3) The control methods available were, in any case, technically inadequate. Therefore, we decided that *Phytophthora* leaf disease did not warrant control in Ceylon, generally. We published this information and based on these publications (Peries, 1963, 1964, 1965, and Lloyd, 1963) all estates made drastic reductions in their estimates for *Phytophthora* control, and the Agency Houses that once estimated to spend Rs. 60/- per acre per year on *Phytophthora* control, reduced their estimates to a token vote of Rs. 1/- per acre—a saving of Rs. 59/- per acre.

The second example I wish to refer to is more significant from the national point of view. The brilliant and painstaking studies of Drs. R. L. De Silva and N. Shanmuganathan at the T.R.I. have led to the reduction of control costs of Blister Blight and *Poria* root disease. I will confine my remarks here to blister control. Studies on the biology of the causal fungus *Exobasidium vexans* and its epidemiology a few years ago, enabled the T.R.I. to advocate a scheme of spraying of blister control which took into account the fungicidal effect of sunshine (Visser, Shanmuganathan and Mulder, 1959; Mulder and De Silva, 1960), i.e. if there were a certain minimum number of hours of sunshine after one round of spraying, the next round could be postponed, thus the number of rounds of spraying were reduced substantially. As more knowledge of the epidemiology of the causal fungus, *E. vexans*, becomes available it would be possible to forecast epidemics more accurately and develop more sophisticated, less expensive spraying schemes (De Silva, 1967). Dr. De Silva has recently studied the effect of blister infection on (*a*) reduction of the photosynthetic area of the leaf, (*b*) the appearance of made tea, and (*c*) the quality of the latter. Carefully controlled experiments to establish the significance of each of these three factors have indicated, that the dosage of copper for Blister Blight control can be reduced without significant effects on yield, or appearance and quality of the made tea. So that, just as *Hevea* can stand some defoliation by *Phytophthora*, a certain amount of blister can be tolerated by tea. Admittedly, further work has to be done to confirm these results, but the effects of these findings are of national importance and are being felt already.

I have dwelt on these two case histories at some length to give some indication regarding the correct sequence of events in plant protection. It is important to control new diseases as soon as they appear in a territory. Watts-Padwick's (1956) studies have shown that certain plant diseases, and probably a high proportion of them, increase exponentially either as regards distribution in a territory or as regards intensity, so that the longer they remain untackled the more intractable they are likely to become. As soon as control measures are well established, however, and it is certain that the disease is not likely to get out of hand, it is essential to study it intensively with a view to minimising control costs. These studies should include the biology of the causal organism, physiology of the host plant, host-parasite relationships, epidemiology of the disease, comparative efficacy or fungicides and application machinery, and last but by no means least, the relationships between weather and the disease. The initial severity of a disease may have been caused entirely as a consequence of favourable weather conditions for the causal organism—we must remember that pathogens can and do cause disease, but it is meteorological conditions which enable them to assume epidemic proportions. As Sir Charles Sherrington (1940) says, "the world is not a product by Chance out of Chaos", there is sense in most things if we look for it, for example people were dead scared of late blight of potatoes till Large (1948) drew the new famous late blight curves—graphs depicting the growth of the tubers in relation to time of year, appearance of blight and application of control measures. It was then found that in many districts blight occurs too late, in most years, for protective spraying to be worthwhile as a general practice. Now late blight control in many countries is a fine art. We can do likewise in the case of other diseases in Ceylon.

It is my firm belief that an important step towards efficient plant disease control lies in the accurate assessment of the amount of damage caused by the disease. For example, in rubber and tea it has been found that a certain amount of *Phytophthora* leaf disease and Blister Blight, respectively, can be tolerated. This type of information helps to cut down on control costs.

There are three main ways in which the significance of plant diseases can be studied: first by intelligence work involving slow accumulation of data about all kinds of diseases over many years; second by extensive surveys of single diseases or groups of diseases on a national or regional basis; and third by intensive research methods carried out on plot and field scale. It might often be possible to do this if a little thought were given to it in the ordinary course of carrying out experiments on the control of diseases in the field.

Plant Pathology must help alleviate the food problem by devising new control measures and improving old ones. It must learn how to control more diseases and how to control many diseases better than is being done now. There must be increased efficiency and decreased cost. This requires experimentation and research. Therefore, if some of the younger people here take an interest in this science, the few minutes which we have spent here, may not be wasted—completely anyway.

References

ABEYGUNAWARDENA, D. V. W. (1967). Recent advances in the control of rice diseases. *Proc. of Symposium on Research & Development of Rice in Ceylon.* Edited by D. V. W. Abeygunawardena.

CONNERS, I. L. (1954). Losses from plant diseases in Canada. *Rept. on the 5th Commonwealth Mycological Conference* pp· 37-39 C.M.I. Publication.

DANTANARAYANA, W. (1967). Ways to economize on insect and mite pest control. *Tea Q.*, **38**, 269-274.

DE SILVA, R. L. (1967). A new look at the economics of blister blight control, *Tea Q.*, **38**, 282-286.

DISRAELI, B.(1845). *Sybil or The Two Nations* Bk 1. Ch. 5.

FERNANDO, H. E. (1967). Recent developments in paddy pest control. *Proc. Symposium on Research & Development of Rice in Ceylon.* Edited by D.V.W. Abeygunawardena.

LARGE, E. C. (1940). *Advance of the fungi.* London: J. Cope Ltd.

LARGE, E. C. (1948). Field trials of copper fungicides. *Ann. appl. Biol.*, **33**, 408-418.

LLOYD, J. H. (1963). The control of abnormal leaf fall disease (*Phytophthora palmivora* Butler) of *Hevea* in Ceylon. *Rubb. Res. Inst. Ceylon, Bulletin No:* 57.

MAGEE, C. R. (1954). Discussion on paper read by E. C. Large. *Rept. on the 5th Commonwealth Mycological Conference* p. 45. C.M.I. Publication.

MOORE, W. C. (1949). The significance of plant diseases in Great Britain. *Ann. appl. Biol.*, **36**, 295-306.

MULDER, D. & DE SILVA, R. L. (1960). A forecasting system for blister blight control based on sunshine records. *Tea Q.*, **31**, 56-67.

ORDISH, G. (1952). *Untaken Harvest.* London: Constable.

PERIES, O. S. (1963). Biology of the causal fungus of *Phytophthora* leaf disease. *Rep. Rubb. Res. Inst. Ceylon.* 1962.

PERIES, O. S. (1964). Review of the Plant Pathology Department. *Rubb. Res. Inst. Ceylon. Rev. for first half year* 1964 (cyclostyled).

PERIES, O. S. (1965). Recent developments in the control of the diseases of the *Hevea* rubber tree. *Q. Jl Rubb. Res. Inst. Ceylon*, **41**, 33-43.

PERIES, O. S. (1966). The economics of disease control in *Hevea. Q. Jl Rubb. Res. Inst. Ceylon.*, **42**, 27-33.

PERIES, O. S. & FERNANDO, T. M. (1966). Studies on the Biology of *Phytophthora medaii. Trans. Br. mycol. Soc.*, **49**, 311-325.

PERIES, O. S. & SAMARAWERA, S. K. (1964). Epidemiology of *Phytophthora* leaf disease. *A. Rev. Rubb. Res. Inst. Ceylon.* 1963.

PERIES, O. S. & SAMARAWEERA, S. K. (1965). Epidemiology of *Phytophthora* leaf disease. *A. Rev. Rubb. Res. Inst. Ceylon.* 1964.

PERIES, O. S. &. SAMARAWEERA, S. K. (1966). Epidemiology of *Phytophthora* leaf disease. *A. Rev. Rubb. Res. Inst. Ceylon.* 1965.

PERIES, O. S. & SAMARAWEERA, S. K. (1967). Epidemiology of *Phytophthora* leaf disease. *A. Rev. Rubb. Res. Inst. Ceylon.* 1966.

RUSSEL, JOHN (1952). Wastage of world food supplies through pests and diseases. Address to International Conference Fernhurst (June 1951).

SHERRINGTON, CHARLES (1940). *Man on his Nature.* Cambridge University Press.

STACKMAN, E. C. & HARRAR, J. G. (1957). *Plant Pathology.* New York: The Ronald Press Co.

VASUDEVA, R. S. (1954). Assessment of crop losses. *Report on the fifth Comm. Mycol. Conf.*, 1954 pp. 42-43 C.M.I. Publication.

VISSER, T., SHANMUGANATHAN, N. & MULDER, D. (1959). The possibility of timing blister blight spraying according to sunshine records. *Tea Q.*, **30**, 39-43.

WATTS-PADWICK, G. (1954). Losses caused by plant diseases in the colonies. *Report on the fifth Comm. Mycol. Conf.*, 1954 pp. 29-37. C.M.I. Publication.

WATTS-PADWICK, G. (1956). Losses caused by plant diseases in the colonies. *Phytopath. Pps.* No. 1. C.M.I. Publication.

WELLMAN, F. L. (1961). *Coffee.* U.S.A., Leonard Hill (Books) Ltd.

WOOD, I. E. (1953). *Three billion dollars a year.* Plant Diseases U.S.D.A. Year Book 1953. Washington: United States Government Printing Office.

SECTION C—ENGINEERING

Presidential Address

SOME ASPECTS OF DEVELOPMENT OF WATER RESOURCES

by

H. de S. Manamperi

Irrigation in Ceylon is at least as ancient as the founding of the first Sinhala Colony in the Island. According to the story of the arrival of Vijaya, he first saw his later consort spinning cotton near a pond. Whether this pond was for irrigation or for domestic water supply, it is clear that the storage of water was an essential ingredient in the life of the people who then inhabited the dry zone of the Island. Vijaya and his successors established themselves in this region where the ancient civilization flourished for many centuries, while at present the wet zone is more fully populated and developed. The first settlers probably preferred a region similar to that part of India from which they came or perhaps the North Central region was less humid and consequently more healthy. It may also have been that conditions in the dry zone were more favourable for agriculture due to higher temperatures and greater periods of sunlight which are factors that influence the growth of crops.

It was necessary to store water in the dry zone area, since most of the rainfall occurs during a few months of the year. The creation of storage works was therefore, necessary for the survival of any community. The large storage works created by the Ancients in the North Central region of the Island provide examples of their intellect and vision. Their diversion from basin to basin are achievements worthy of the highest admiration, considering the nature of the tools that they had at their disposal, both for planning as well as execution of works. It has often been said that the ancient people grew sufficient food for themselves and even for export. Since transport was primitive, and communications slow, it would have been necessary for each community to grow its own food in order that it may survive. If sufficient food was not produced a certain section of the population would have died, thus creating a balance between population

and food supply. This selfsufficiency in food that is claimed as an achievement of the Ancients was merely the attainment of a balance between supply and demand. This would appear to be an unpatriotic statement on my part. Nevertheless, we have to accept facts as they are, and not be lured a realm of fantasy not justified by scientific deduction. While our ancient heritage is worthy of pride, it should not condition our minds to believe that what was done then, is the best that can be done today. The several thousands of small village tanks scattered all over the Island, some now restored and some still abandoned have created a popular misconception that the food problem of this country can be solved by the restoration of these works. The recent emphasis on the restoration of village irrigation works is not the answer to the food problem of this country, however, desirable it may be from other considerations, which apparently seem to exercise greater influence in this matter, than sober scientific thinking.

With very few exceptions, the larger irrigation works have now been restored. A few, such as Wahalkadawewa in the Anuradhapura District and Pimburattawawewa in the Polonnaruwa District await restoration. When the restoration of large reservoirs such as Mahakandara Wewa and Padaviya was receiving attention, the established policy of development was to provide irrigation water for the cultivation of rice for the *maha* season only. The argument used in its favour was that larger number of people could be settled on the land than if two season cultivation was planned. This decision overlooked certain basic, economic and human factors which should have received due attention. Assuming that the cultivation of a crop for one season would bring an adequate income to maintain the family of a colonist for the whole year, it still leaves a wide open question mark in respect of the occupation of these people during the rest of the year. It cannot be said that in any of the schemes designed purely for a *maha* cultivation, there has been an adequate income from paddy cultivation alone for the maintenance of a colonist and his family throughout the year. In order to obtain an adequate income, there has been a clamour for the supply of irrigation water during the dry season as well. This has resulted, in some instances, in the increasing of the capacity of storage works, on an ad hoc basis. Even this does not satisfy the requirement of providing assured water supply for all lands during the dry season.

The one season system entails additional expenditure in the construction of channels. It is also wasteful in land use. Developed lands are used only for 6 months of the year, and lie fallow for the rest of the time. Therefore, in the irrigated areas, land use efficiency is only 50% assuming that water is available every year for wet season cultivation. This indeed is far from being the case. Quite often when the October to January rainfall does not yield sufficient water, only partial cultivations are possible.

While roads, schools and such facilities have normally been made available in all major irrigation projects, the very essential facility of domestic water supply has not been paid sufficient attention. In many major schemes, the supply channels are used for the bathing of cattle, washing of tractors and for domestic purposes. In schemes where only a *maha* cultivation is possible, water supplies to communities which are strung along the major channels, provide an acute problem. Occasional issues are made along the channels, when water is available in the tank. This results in an unnecessary wastage of water by absorption and seepage through the canal bed and banks. These, then, are some of the problems created by the former policy of one season cultivation.

As discussed above, even in major schemes which are designed only for *maha* cultivation, economic and social problems are invariably present and are inherent in the structure of the development itself. It should be apparent therefore that these problems should in a more severe form occur in village works restoration.

Village works suffer from further disabilities. The water supply to these small storage tanks is received from local rainfall and is therefore unreliable for organised cultivation. Besides, only a *maha* cultivation is possible even in years of good rainfall. Another disadvantage is that these shallow tanks occupy approximately the same extents of land as would be commanded by them. Sometimes the water spread may even exceed the area of land commanded. On the basis of a one to one ratio and taking into account that only a *maha* cultivation is possible on the full acreage commanded, then the efficiency in land use is reflected in the fact that to obtain a crop on one acre of land, two acres of land have to be used. Since only one cultivation is possible during the year, the land use efficiency reduces to 25%. It is also known that quite often the pattern of rainfall distribution makes a successful cultivation under these tanks possible about 60% of the time. Thus the land use efficiency is further reduced. In contrast, the Uda Walawe Reservoir with a water spread of some 8000 acres will irrigate 60,000 acres of land for the whole year, and will supply *yala* deficiencies to about 20,000 acres of rice cultivation.

Besides, the poor land use efficiency, the undependable supply of water in these schemes makes scientific agriculture practically impossible. The effective application of fertilizers and such improved cultural practices is not practicable. The social, economic and human problems that arise in consequence of village works restorations need no repetition. They are certainly more acute than comparable problems in major development schemes.

It would be far better to leave these small tanks and the areas commanded by them in forest than to restore them at great expense for the uncertain irrigation of a few acres of land. One clear pointer to the failure of these works is that they are seldom maintained by the cultivators, once the construction has been completed. The result is that they come on the priority list of the District Agricultural Committees time after time for major repairs. Annual maintenance which is the duty of the cultivators would prevent such high expenditure in repeated improvements. Some blame the indiscipline of the people and the absence of enforcement of the Irrigation Ordinance for this condition. While this may be a contributary factor to the neglect of these works, the main cause appears to be that the returns are apt to be poor and therefore there is no incentive to expend time and effort on the maintenance of such works.

Some say that Ceylon is a country with vast natural resources. However, the recent Interim Report on the Mahaweli Project issued by the UNDP/SF Team, states "Ceylon is poorly endowed with natural resources". What then is the factual situation?

With the exception of some bauxite, iron ore, monazite sands, and gems, Ceylon has no mineral deposits of significant value. Its main exploitable resources are land and water. The annual average rainfall in the Island varies from 40 inches in the North Western and South Eastern Dry Zones to over 200 inches in some regions around Sri Pada. These figures have to be viewed on the basis of the actual areas receiving the rainfall, the distribution of such rainfall and topographical and climatic factors affecting the availability of this rainfall for utilisation.

Of the 16 million acres of the Island, 82,000 acres (0.5%) receive annual average rainfalls over 200 inches, 2.76 million acres (17%) between 200 and 100 inches, 3.07 million acres (19%) between 100 inches and 75 inches, 7.36 million acres (46%) between 75 and 50 inches, 2.31 million acres (14%) between 50 and 40 inches and 614,000 acres (4%)

below 40 inches. The pan evaporation in the Dry Zone is around 72 inches per year. About two thirds of the total area receives less than 75 inches of rainfall. This is an indication of the need for irrigation water for plant growth in the Dry Zone.

The total average annual volume of rainwater falling on the Island is 107 million acre feet. The average annual discharge of surface water into the sea from all rivers and streams in the Island is estimated at 35% Million Acre Feet—approximately one third of the precipitation. Most of the balance is expended in evaporation and transpiration, while a small percentage seeps into underground storage.

The actual discharge into the sea works out at an average of 26½ inches of depth over the total area of the Island.

The total quantity of water used for irrigation in the Island is less than 5 million acre feet or 14% of the runoff into the sea. A large volume of water is therefore available for agricultural purposes. Much of this water is available in the South Western Wet Zone of the Island. Trans-basin diversions are therefore necessary for its utilisation.

The development of the Island's hydro-power potential poses several problems. The UNDP Survey of the Mahaweli Ganga places the planned firm power potential of the Resources of the Basin at 210 Megawatts and a production capacity of 2380 million KWH., with an installed capacity of 460 MW. The Capital expenditure for the development of power, excluding the cost of transmission lines is estimated at Rs. 900 million.

The Kalu Ganga Basin is tentatively planned for a generation capacity of 570 million KWH., with an installation of 140 MW. The corresponding figures for the Kelani including plant in commission are 1230 million KWH., and 290 MW., for the Walawe 420 million KWH., with 125 MW.

The Mahaweli, Kelani, Kalu and Walawe Gangas draining approximately 30% of the Island and discharging 22 million acre feet of water or 60% of the surface runoff annually, have a planned total generation of 4580 million KWH. This will probably suffice for the next 15 to 20 years.

The topographical features of the Island are such that generally when a significant volume of water is available in a stream for the production of power, the water course has already reached elevations too low to provide a high head. In these situations Hydro-Power production is comparatively expensive.

We are thus faced with the challenge of evolving ways and means of economically transferring water from surplus areas to deficient areas for agricultural purposes, and to produce power economically from the only local source of energy. For this latter purpose, we should not forget to harness the small power potentials available in our major reservoirs, and canal falls.

Hydro-power from these reservoirs and canal falls is available only during periods of water issue. The utilisation of seasonal power needs imaginative thought on the part of our scientists. One favourable factor operating in these areas is that the labour force employed in agricultural operations is unemployed or under employed during periods of water issue. The absorption of this labour force into productive work will ease a social problem, apart from increasing national wealth.

The investigation of large works, and preconstruction studies occupy a great deal of time.

Civil engineering by itself is one vast approximation. It is nevertheless the duty of the civil engineers to minimize the difference between estimated cost and the actual cost. Considerable time and effort have to be expended in this process.

The first step in project preparation is what is termed a Reconnaissance Survey of the Project. This is mainly an office study supplemented with a few inspections and perhaps some minor surveys. Assuming that the project is one for irrigation and power from a storage reservoir, we have the following materials available for the assessment of the possibilities of the project.

1. Topographic maps to the scale of 1": mile with 100 foot contours, which cover the whole Island.
2. Topographic maps to the scale of 2": mile with 20 foot contours which cover some parts of the Island.
3. Aerial Photographs (Stereo Pairs which cover the whole Island).
4. A provisional geological map of the Island showing the main geological features.
5. A land classification map of the Island showing different soil types.

6. A land use report which indicates the different types of forest cover, cultivation etc.
7. Rainfall and climatic data at various stations throughout the Island.
8. Run-off data on the major rivers and streams.

Utilising the data that is available in the above, it is possible to assess approximately the quantity of water that could be obtained for regulation at the selected site or sites. It is possible also to roughly layout the area that could be commanded by the storage works. Field inspections of the site and the area that could be commanded will indicate the nature of preliminary surveys that would be necessary to obtain a very approximate cost of the proposal. Such surveys would be limited to a cross section at the site of the proposed dam, a few sugar holes to determine the nature of the foundation, and a rough assessment of the local materials that would be available for construction. Based on this data and a few sketches showing the headworks and the probable layout of the schemes computations can also be made to determine the power potential and the cost of the power installations of the Project. The Reconnaissance Report prepared on this basis would include very approximate costs and benefits of the proposal. The preparation of such a report would take three to six months, depending on the magnitude of the work, field work involved, site conditions etc.

If the Reconnaissance Report indicates that the project is reasonably favourable, a feasibility study is next undertaken. A feasibility study is a much more detailed operation. Such a study is meant to elucidate the economics of the project, the approximate costs involved both in local and foreign expenditures, the probable phasing of the project and most important, its integration with the overall pattern of development of the Island. In most multi-purpose projects in Ceylon, agricultural benefits far outweigh the Hydro-Power and flood control benefits. For example, the Interim Report of the UNDP/SF Team, on the Mahaweli Ganga Development, has arrived at an overall annual agricultural benefit of Rs. 1127 millions while the corresponding power benefit is Rs. 84 million. Agricultural benefits depend on the cropping pattern adopted. In the proposed Mahaweli development, the main *added* agricultural benefits are vegetables Rs. 303 millions, groundnut Rs. 216.6 million, paddy Rs. 488.0 million, chillies Rs. 103 million, cotton Rs. 80.5 million, Bombay onions Rs. 65 million, green gram 59 million, citrus, maize, milk about Rs. 50 million each. The nett farm incomes from these crops vary widely with Bombay onions at Rs. 1622, vegetables at Rs. 1257 per acre and paddy the lowest at Rs. 390 per acre.

Agricultural benefits, and consequently project economics are dependent on the type of cropping pattern adopted. The importance of integration of projects into an overall development plan is therefore vary apparently.

The economic feasibility of a project depends therefore not on an arbitrary pattern of agricultural development but on the context of the overall needs of the economy of the country. The preparation of engineering designs and estimates is a comparatively straightforward operation.

The preparation of engineering designs and specifications for a feasibility study needs such services as—

1. detailed topographic surveys
2. geophysical surveys
3. drilling and geological investigations
4. soils and construction materials investigations
5. soil survey and land classification
6. hydrologic studies to determine yields and flood discharges
7. water quality analysis
8. investigation of permeability characteristics of soils
9. in situ-elastic properties of rocks
10. possibilities of water losses through reservoir beds
11. cropping patterns.

These investigations and attendant designs may take from 2 to 4 years depending on the magnitude of the project. A Feasibility Report would generally include discussions on technical criteria and parameters of selected features, and an economic evaluation of the project.

Feasibility studies lead to the establishment of the main parameters of engineering features within very close limits, and provide close approximations of their costs. The requirements of materials and equipment for construction, local currency and foreign exchange requirements, phasing of construction works and expenditure are worked out in fair detail. Cropping patterns are established, infra structure requirements are evaluated, and economic studies are made. A feasibility study provides sufficient information for the Government to decide on acceptance or rejection of the project, and if accepted the most opportune period of implementation to fit it into the Country's overall development plan.

The Government's Central Planning organisation has to use the information in the Feasibility Report to ensure that attendant Ancillary services and social services are geared to the requirements of development. It has also to ensure that the products of the projects are utilised to the best advantage.

The next stage in the engineering process is the preparation of final designs. I may explain that the term final designs is a misnomer. In civil engineering practice the final design is available only after the completion of the work. What is called the final design is, then, only the preparation of designs, plans and specifications which will enable construction work to be begun on a rational, sound and safe basis. Quite often these designs themselves have to be changed depending on conditions that may arise during the course of the work.

Subject to the limitations mentioned above, a final design provides all plans and specifications of engineering features, and a development plan for the use of the resources created by the engineering works. In the case of an irrigation project, it will include the development pattern of the area to be irrigated, different areas devoted to different crops, canal and road systems, villages and towns etc.

The preparation of final designs and plans occupies varying periods of time depending on the magnitude of the project and the types of engineering features included in it. In the case of large projects, therefore, it is not customary to await completion of all designs prior to commencement of construction. Design work is phased out so that they are made available sufficiently in advance of the phased construction programme established after a study of the Feasibility Report.

The most difficult phase of resources development is that of construction. This is primarily due to the large volume of money, materials and men that have to be mobilised. While these are major problems even in developed countries, they present more acute and much greater problems in Ceylon. The shortage of money for investment in development projects is well known. One of the contributary causes of this shortage is the emphasis placed on current consumption especially in absolutely non essential items. It is understood that we must clothe ourselves. But should

we clothe ourselves in dacrons and terylenes and nylons which do not even suit our climate. It is true that our children like sweets as do all children. But must we encourage the consumption of imported sugar by turning out the most delicious chocolates and pack them in eye catching boxes equivalent to those in the most affluent of societies? Must we expend foreign exchange, time and energy on the manufacture of chewing gum? Must we manufacture asbestos sheets when local material is available in sufficient quantity and of suitable quality to provide all the roofing material we need.

To proceed into the field of construction materials we find such procedures as are difficult to understand. In Europe, and in the U.S.A. construction in concrete has been developed to a fine art. Concrete in essence consists of small pieces of stone converted into large blocks by pouring a mixture of these small pieces of rock, sand, cement and water into wooden or metal boxes. This is a classical construction material of Europe. This development came about because river shingle, cobbles, gravels and sand were naturally available in deposits in those countries.

In Ceylon, the classical construction materials were stone and earth. There were no large deposits of water borne shingle, cobbles or gravel. Even river sand is a scarce resource. Stone was available in plenty and was of excellent quality. Clay for bricks and tiles was abundant. Therefore, the ancient engineers and craftsmen of this country created engineering monuments in stone, and bricks and earth.

The natural development of construction materials in this country should have been in the direction of mechanisation of stone construction not only for structural strength but for beauty. Which concrete can be compared with the rose pink of the Tonigala granite or the sheen of the quartzites so abundant in the dry zone? Our British masters built magnificient structures out of stone and they stand to this day as monuments of engineering achievements.

Diversion weirs across the Deduru Oya, at Batalagoda, the Walawe Ganga at Liyagahatota, and the Kirindi Oya at Tissamaharama, are still as good as new after 60 years of active service. The same can be said of the many hundreds of piers carrying roads and railways over them. The logical development in construction would have been to mechanise the process of construction in stone. But this was not be.

We have found it better to import blasting materials and machinery, blast stone; import crushing machinery to crush the rock, screening equipment to screen it, batching plants to mix it, cement to build it together again, cooling equipment to absorb the heat of hydration, steel formwork to pour the mixture into, spraying equipment to cool and cure the blocks, drilling and grouting machinery to rectify the honey combing that sometimes occur in poured concrete and so on.

Our philosophy then is to break natural stone and make a lower quality imitation material. This is in the same strain of thought in which we wear socks and shoes, shirts, ties, coats and so on, and when we find ourselves warm we spend money on air conditioners for houses and offices, and then catch colds and chills, and pay for imported medicines to cure us.

Our major item of construction work in resources development is earthwork in canals, for which unskilled labour can be used in plenty. The 54 miles long Jayaganga, and the Yoda Ela reaching from Elahera to Kantalai a distance of 60 miles, are two outstanding examples of major canal construction undertaken by ancient engineers of this country. All this was handled by manual labour supplemented perhaps with draft animals. This same means can be usefully employed in canal construction today, without expending foreign exchange on the purchase and operation of heavy construction machinery. Such a procedure would also utilise the large numbers of unskilled unemployed whose work capacity is not utilised for productive work.

The method used in the exploitation of natural resources should be in keeping with local conditions. It is indeed axiomatic that locally available skills and materials should be used in preference to imported ones. This is an aspect which needs deeper and keener attention than has been the case in the past. People who are more fortunately placed than the vast mass of the population in having been able to visit foreign countries and study foreign techniques should not merely copy such techniques. They should use the knowledge they gain to adapt local resources to the best advantage.

The mobilisation of manpower resources is an essential ingredient in any resources development programme. Two decades of complete political independence and an almost equally long period of semi independence have not sufficed to establish a sound and progressive economy

in this country. This points to a weakness in the mobilisation and direction of our manpower which is our greatest resource. Unless manpower is properly mobilised, natural resources will remain unutilised or be poorly utilised or even misused. In this era of commissions, it would be very appropriate to appoint a commission to inquire into manpower mobilisation in this country. Such a commission would probably study the suitability of our political institutions for the effective mobilisation of our manpower. It would study the contribution made by an administration still conditioned by a colonial era, to a stagnant economy. It would evaluate the effect on our manpower resources, of the steady and very ready inflow of experts into this country.

There are no doubt experts, and experts. I welcome the services and presence in this country of experts respected in their own countries, and who have proved their ability in their own fields of specialisation. I do, however, having met many experts of both types, question the value of the expert who is an expert only because he hails from beyond our shores. The importation of such experts causes a lowering of the morale of our own Scientists and technologists. Many a time, I have heard it said "Well they have got an expert to tackle this job. Let him do it. Why should we bother".

All I say is let us create our own experts. And when they have been created, let them work in their own fields of specialisation. Let them be paid adequately so that they may concentrate on their work without having to think of where the next meal comes from. Let us follow the examples of the U.S.A. and the U.S.S.R. which imported no experts but developed their own. Let us follow even more closely, Japan a country which sent its young men abroad for training and created a dynamic economy in a period of less than 50 years.

That we must have efficient men for the development and utilisation of our resources is a truism. It is also true that the development of our water resources is a function of the State. Competent men of proven ability, and integrity with a capacity for hard work and deep devotion to duty must be placed in positions of reesponsibility irrespective of all other considerations. The structure of the Public Service in Ceylon is not favourable for this necessary condition. The passage of time seems to be the sole avenue of promotion in the Public Service which is geared primarily to look after the promotional prospects of its employees rather than to executing development programmes efficiently.

Time is flying fast. The scientists and technologists of this country have to provide the intellectual wherewithal necessary to raise the living standards of our people. They would like to do this as proudly as their forebears did, with the resources of this country and the minimum of assistance from our friends in all parts of the World. They are ready to meet the challenge, and given the opportunity they will not fail—they will succeed!—thank you.

SECTION E—PHYSICAL SCIENCES

Presidential Address

ENZYMES—THE CORE OF LIFE

by

M. C. KARUNAIRATNAM

At a meeting of the British Association for the Advancement of Science in 1934, the famous English biochemist and Nobel Laureate Sir Frederick Gowland Hopkins made the following remark:—

> "By the essential and ultimate aim of Biochemistry I mean an adequate and acceptable description of molecular dynamics in living cells and tissues".

Biochemists all over the world are still striving towards this goal.

Every living thing from man to microbe, plant or animal is a complicated chemical machine. Biochemistry seeks to explain how this machine operates in terms of atoms and molecules. The fundamental unit of all living systems is the cell. It must be able to take up nutrient material from the surrounding fluid and must transform them into new parts of itself before it can grow and reproduce itself. It should also be able to break down some of these nutrients to provide energy needed for the synthesis of the complex cellular material and for the performance of various types of work. The necessary machinery for these activities must be present within the cell. Basically therefore, the primary purpose of the cell's machinery is to convert nutrients into useful energy and at the same time to create the new carbon skeletons that are needed to synthesize other vital compounds. These molecular rearrangements and transformations comprise the metabolic activity of the living cell. Research into the cell's metabolism has been a primary activity in the field of Biochemistry for the last 75 years.

When biochemists started exploring these molecular transformations, they were struck very forcibly by three characteristics:—

1. The *rapidity* with which cells carried out these transformations. e.g. atmospheric CO_2 is incorporated into the cellular sub-

stance of a green leaf within a few seconds. A bacterial cell synthesises its own weight of cellular substance in about 30 minutes.

2. The *precision* with which they are carried out. The reserve carbohydrate stored in the liver is always glycogen. It is never starch or cellulose. The carbohydrate in a mother's milk is always lactose and not sucrose or maltose.

3. The *mild conditions* under which the reactions are carried out. Proteins are broken down to amino acids in the alimentary canal within a few hours at body temperature. The amino acids absorbed from the small intestine are built into complex tissue proteins within a few minutes at body temperature and in a near neutral medium. Some of these reactions have not yet been achieved in the laboratory by the organic chemist. Others require drastic conditions like heat and strong acids or alkalis.

How then is a living cell able to carry out such complicated reactions so rapidly, so precisely and under such mild conditions? All this is possible because of the presence of a group of substances called ENZYMES in all living cells. These are biocatalysts. Every single molecular transformation within the cell is catalysed by an enzyme. There are thousands of them present in a cell; each one catalysing a single molecular transformation or a single type of chemical reaction. The result of the organised activity of the enzymes within a cell is what we call Life. Enzymes then may be truly regarded as the CORE OF LIFE.

DISCOVERY OF ENZYMES

From prehistoric times mankind has made use of enzymes, without his realising it, in making wine from grape juice, cheese from milk and in making bread. It was only in comparatively recent years that we have acquired any knowledge or understanding of enzymes. This knowledge came chiefly from studies on the chemical mechanism of digestion and fermentation.

Van Helmont in the 17th. century was the first to suggest that digestion involved an actual chemical transformation of foodstuffs through the agency of ferments. He considered the process of fermentation of wine also as chemical in nature. The first convincing experiments in support of Van Helmont's theory were probably those of Reaumur in 1752. He fed birds different types of food material enclosed in perforated metal tubes. When the birds ejected the tubes from the stomach he examined

what was left in the tubes and concluded that stomach juice had a certain solvent power on foods. The nature of this agent however remained a mystery. Schwann in 1836 described a constituent in stomach juice which degraded proteins. He called it pepsin. Twenty years later in 1856, Corvisart described a protein splitting component in pancreatic juice which he called trypsin.

During the early part of the 19th. century, Kirchoff noticed that starch could be broken down to glucose by the action of dilute acids and that the acid itself was unchanged by the process. Berzelius (1836) called this phenomenon catalysis and the responsible agents were called catalysts. Digestion and fermentation were included among the catalytic processes. During the next few years a number of catalytic processes were discovered in biological material. Ostwald defined a catalyst as a substance that "changes the rate of a chemical reaction without appearing in the final products of the reaction". Although the phenomenon of catalysis was more or less well established and the presence of catalysts in biological material was recognised, what was not known was their chemical nature or their mode of action.

It was demonstrated independently by Latour, Kutzing and Schwann that yeast was composed of living cells which grew and multiplied during the fermentation of sugar. The question naturally arose whether the ability of the yeast cells to breakdown glucose to alcohol and CO_2 depended on the life of the yeast cells or whether the yeast cells contained a ferment which could breakdown the sugar independently of the life of the cells. Louis Pasteur put forward his "No fermentation without life" theory. This vital theory was vehemently opposed by Liebig and Wohler—two of the leading scientists of the day. Liebig held that the nitrogenous material of the fruit juice was a ferment which was unstable in the presence of air and underwent a progressive change. During this process, it communicated its instability to the sugar molecule which then broke down to CO_2 and alcohol. He supported this theory with a number of chemical analogies. So great was his reputation as a scientist that this view of fermentation was widely held and taught for several years.

In 1878, Kuhne introduced the term "enzyme"—which literally means "in yeast"—as a general term for all biological catalysts. He felt it was unnecessary to distinguish between the "unorganized ferments" like pepsin and trypsin of the digestive tract and the "organised ferments" found within the yeast cells and lactic acid bacteria.

In 1897, twenty four years after Liebig's death and two years after Pasteur's, a chance discovery by Eduard Buchner, Professor of Chemistry at Tubingen University, settled the dispute between the followers of the "vitalistic" and "non-vitalistic" theories. He had prepared a cell free extract of yeast for some of his nutritional experiments. As he had to keep this extract till the following day he added a little sugar as a preservative. To his great amazement he noticed bubbles of gas escaping from the surface a few hours later. This accidental discovery by Buchner that a cell free extract of yeast could ferment sugar may be regarded as one of the notable milestones in the development of Biochemistry. Buchner was awarded the Nobel prize for this discovery. Many regard this discovery as marking the beginning of modern Biochemistry. In many regards, "Biochemistry" has virtually become synonymous with "Enzymology".

Pasteur was partly correct and partly wrong. Living yeast cells were necessary for the formation of the ferment but were not necessary for its activity. The cell free extract was called "zymase". It made it possible to study fermentation in the absence of living cells. Rapid progress has been made in the field of enzymology during the last seventy years.

THE CHEMICAL NATURE OF ENZYMES

The early experiments with zymase indicated that enzymes were proteins. The enzyme urease was the first to be isolated in a crystalline form by Northrop in the 1920s. Since then over 700 have been obtained in a pure form and about 125 have been crystallised. All these have been shown to be protein in nature. Some of these enzymes are simple proteins while others are conjugated proteins. The non-protein component is referred to as a coenzyme, prosthetic group or an activator. Vitamins form an integral part of the coenzyme or prosthetic group while the activators are usually metallic ions. Enzymes therefore may be regarded as proteins with catalytic properties. They show all the physical and chemical properties characteristic of proteins.

The sequence in which the amino acids are joined to each other in the protein molecule is referred to as the primary structure. One protein differs from another not only in the relative amounts of the twenty basic amino acids present in the protein molecule but also in the sequence of amino acids in the protein molecule. The long protein molecule assumes a helical structure—secondary structure—and the helix in turn coils up to form a globular structure—tertiary structure. This coiling up does not

happen in a haphazard manner but it is determined by the primary structure of the protein molecule. All proteins with the same primary structure will have the same secondary and tertiary structures in their native state. The forces involved are hydrogen bonding, electrostatic forces between charged groups and van der Waal's forces. A gene mutation causing a change in the primary structure of the protein, the application of heat, a change in the pH of the medium or the presence of certain chemicals cause changes in the secondary and tertiary structures of the protein molecules. The process is referred to as denaturation and is often associated with a loss or marked change in the biological properties of the proteins.

CATALYTIC ACTIVITY AND SPECIFICITY

The catalytic activity of the enzyme is indeed a remarkable property. Only such reactions which may, by the laws of thermodynamics, proceed spontaneously will be subject to perceptible catalysis. A solution of sugar in water exposed to air is at a high energy state and will inevitably react to

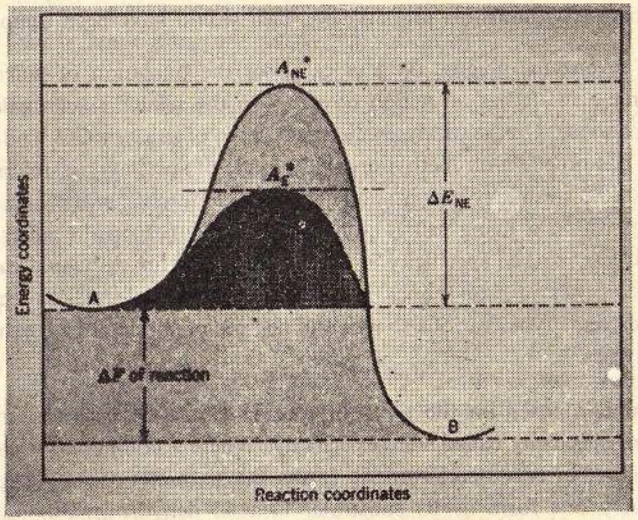


Fig. I

A diagram showing the energy barriers of a reaction A—>B. A_{NE}* indicates the activated complex in a nonenzymic reaction and A_E* the activated complex in an enzyme catalyzed reaction. A is the initial substrate and B the product. $\triangle E_{NE}$ is the energy of activation for nonenzymic and $\triangle E_E$ for the enzymic reaction. $\triangle F$ is the difference in free energy in A—> B.

yield CO_2 spontaneously. However, if such a solution is sterile and free of enzymes it may be preserved for years without measurable change. Add a small quantity of the appropriate enzyme mixture and in a matter of minutes CO_2 gas commences to evolve. Somehow the enzymes have overcome the energy barrier imposed by nature on the oxidation of sugar. We say the energy of activation has been reduced in the presence of the enzyme and more substrate molecules now undergo a chemical change per unit of time. e.g. one ounce of an enzyme preparation from the hog's stomach will digest 50,000 ounces of boiled egg white in 2 hours. This same preparation will also clot 2,800,000 quarts of milk!

Many inorganic catalysts known to the chemist exhibit similar if quantitatively less imposing effects. But what distinguishes an enzyme from an inorganic catalyst is the property of specificity of action. Unlike an inorganic catalyst an enzyme very often catalyses a single chemical reaction or at the most a single type of reaction. This property of enzyme specificity is one of the most important of biological phenomena. It exerts a directive influence on the metabolic reactions within the living organisms. Without this property life itself would have been impossible.

The enzyme glucose oxidase catalyses the oxidation of glucose to gluconic acid. It has no action however on the related sugars galactose and mannose. Urease catalyses the breakdown of urea to CO_2 and NH_3, but it has no effect on methyl urea. This type of specificity is referred to as absolute specificity and is shown by a large number of enzymes functioning within a living cell. The hydrolytic enzymes on the other hand exhibit less marked specificity in their action. The lipases would catalyse the hydrolysis of ester bonds in any triglyceride molecule. In between these extreme types various shades and degrees of specificity are exhibited by enzymes.

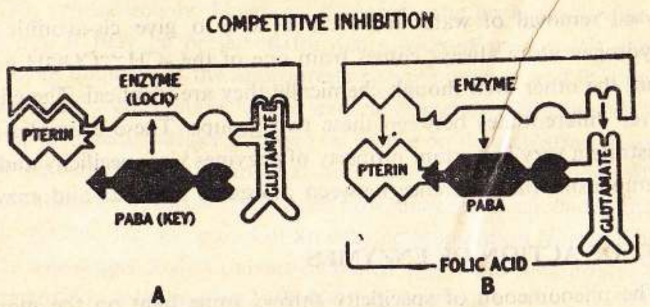
Superimposed on the types of specificity just described is another form of specificity called stereospecificity. Where a compound is capable of existing in two stereoisomeric forms the naturally occurring enzyme uses only one form as its substrate. L-lactic dehydrogenase found in muscle tissue will oxidize L-lactic acid to pyruvic acid. It has no effect on D-lactic acid. Sometimes the stereospecificity is in relation to the product and not the substrate. Succinic dehydrogenase oxidises succinic acid to fumaric acid, the trans-isomer, and not to maleic acid the cis-isomer. The enzyme sometimes goes a stage further and differentiates between groups in a molecule which are chemically indistinguishable. In an enzyme

catalysed removal of water from citric acid to give cis-aconitic acid, the hydrogen atom always comes from one of the $-CH_2 . COOH$ groups and not the other even though chemically they are identical. The enzyme however differentiates between these two groups. These examples serve to illustrate a very important property of enzymes viz; specificity and they also emphasize the difference between inorganic catalysts and enzymes.

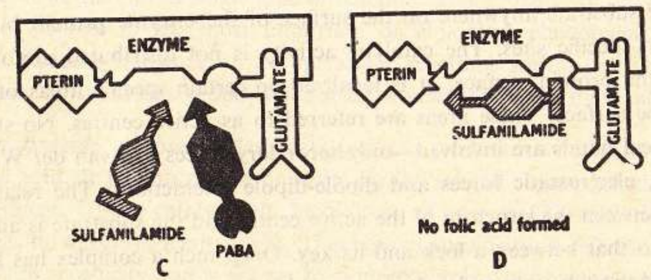
MODE OF ACTION OF ENZYMES

The phenomenon of specificity throws some light on the mode of action of enzymes. Specificity implies that a certain amount of structural specialization is required by the enzyme in its substrate. This in turn demands a corresponding structural specialization in the enzyme molecule itself. To explain specificity one has to think in terms of an enzyme-substrate complex formation as an intermediary stage; not mere adsorption of the substrate anywhere on the surface of the enzyme protein but at certain specific sites. The catalytic activity is not distributed uniformly over the protein surface. It is localized on certain specific areas of the enzyme surface. These areas are referred to as active centres. No stable chemical bonds are involved—only secondary forces like van der Waal's forces, electrostatic forces and dipole-dipole interactions. The relationship between the structure of the active centre and the substrate is analogous to that between a lock and its key. Once such a complex has been formed the substrate molecule is activated in some way or other and undergoes a chemical change quite readily. The activation may be due to a change in the electronic configuration of the molecule. Various theories have been developed with reference to particular enzymes but a general theory of enzyme mechanism still remains a goal and not an achievement. Support for enzyme-substrate complex formation comes from spectroscopic data, isolation of crystalline intermediary compounds and kinetic studies.

What happens if you introduce a compound with a structure somewhat similar to that of the substrate into an enzyme catalysed reaction system? The enzyme catalysed reaction is slowed down and sometimes stopped altogether. We call this competitive inhibition of enzyme activity. The inhibitor molecule resembles the substrate molecule close enough to compete with it for the active centre on the enzyme. This resemblance however is not good enough for the molecule to fit perfectly into the active site and get activated and undergo a chemical change. Thus sulpha-



Folic acid is composed of three pieces (a pterin, PABA and glutamic acid). These pieces fit perfectly onto the enzyme surface (A), and snap together forming folic acid. The completed molecule drops off the enzyme (B) and the process repeats (the key fits the lock and opens it).



Sufanilamide is an analog (close chemical relative) of PABA. It competes with PABA for the enzyme site (C). Sulfa can attach to the enzyme surface, but the fit is imperfect (D) and it does not react with the pterin or the glutamic acid (the key fits the lock, but can't open it).

Fig. II

nilamide competes with p-aminobenzoic acid for the enzyme system catalysing the synthesis of folic acid in the micro-organism *Streptococcus haemolyticus*. The competitive inhibitor is like a key which fits a lock partly and jams the lock. The failure to synthesize folic acid results ultimately in the death of the micro-organism. Why does the drug cause harm only to the bacteria and not to the cells of the person infected with the pathogenic bacteria? The answer is simple. In man folic acid is not synthesised in his cells. It is supplied to him in his food and hence the

question of interference with its synthesis does not arise. The concept of competitive inhibition provides us with a rational approach to the search for new drugs. If however a drug like carbon monoxide is introduced, it combines with iron atoms which form an integral part of the oxidising enzyme cytochrome oxidase in our cells. Energy production is interfered with and carbon monoxide proves fatal. Poisons act by inhibiting essential enzymes in living cells.

Specificity of enzyme action depends therefore on a perfect fit between enzyme and substrate molecules. Any modification of the substrate molecule will lead to an imperfect fit, no substrate activation and therefore no reaction. The number of active centres is usually between one and four per molecule of enzyme. The active sites appear to be of quite limited dimensions. Most enzymes are inhibited by binding various small molecules. In many cases just one molecule of inhibitor is sufficient to block enzyme activity. A number of cases are known where a major fraction of the enzyme molecule may be removed without destroying its enzyme activity. Several enzymes e.g. trypsin, occur as inactive precursors which may be activated by localized alterations in the structure of a particular region of the molecule. The active centre is usually associated with one or more of the following groups:—the OH of serine, the –SH of cysteine, the –OH of tyrosine, the imidazole group of histidine, the $-NH_2$ of lysine or –COOH of aspartic acid. When more than one group is associated with the active site, it does not necessarily mean that these groups should be close to each other on the enzyme protein chain. Even though they may be far apart in the peptide chain, they may be brought close to each other on the enzyme protein surface as a result of the particular tertiary structure of the enzyme protein. Any alteration of this tertiary structure by heat, change in the pH or by chemicals would destroy the active centre and hence enzyme activity.

MICROBIAL ENZYMES

Microbes may be regarded as "bags" of enzymes. During their growth a large number of reaction products are secreted into the medium and some of these are of industrial importance. The ease with which the micro-organisms effect many of these changes, some of which are extremely difficult or impossible to carry out in the chemical laboratory, is the envy of the industrial chemist. The chemist himself has taken to using microbial enzymes to bring about certain chemical transformations which have proved difficult or time consuming using conventional techniques. Among such products are various alcohols, organic acids, antibiotics and vitamins.

In food processing techniques, enzymes have a distinct advantage over conventional chemical reagents. They are non-toxic. Their specificity of action allows them to be used in complex food mixtures without causing undesirable chemical changes. A number of carbohydrate and protein splitting enzymes have been used widely in the food and confectionery industries. Pectinases are used in the processing of fruit juices. They help to reduce both the haze and viscosity and make the juices more suitable for concentration or fermentation. Pectinases also play a role in the retting of fibres.

Microbial enzymes in addition to being useful are also essential to the life of man. Soil bacteria transform dead animal and plant tissues into simple compounds which are re-used by subsequent generations of living organisms. If this were not so, carbon, hydrogen, oxygen and nitrogen would stay bound within the large molecules of dead matter and remain unavailable for the living. Under such conditions all life would eventually end owing to a deprivation of these very elements. The same carbon, hydrogen, oxygen and nitrogen atoms in the world today existed at the time the earth was born. It is theoretically possible that the atoms in your body may have been part of the body of a prehistoric fish or a giant fern or a New Stone Age man. Viewed in this light, the living world could well maintain itself without man but man could not long survive without the enzymes of his microbic allies.

Enzyme preparations have also been used for therapeutic purposes. Proteolytic enzymes have been used locally for the debridement of wounds, intravenously or intramuscularly for treatment of inflammatory conditions. Deoxyribonuclease helps to clear the respiratory tract and also hastens the cure of meningitis and lung abscess. New fields that seem potentially profitable are the investigation of the effect of fibrinolysin and lipase on atherosclerosis and the effect of enzymes and their inhibitors on the spread and dissemination of cancer.

I would like to mention here a few enzymes which are fascinating. The enzyme luciferase is responsible for the glow of the firefly, and the luminescence of certain microorganisms which light up the wake of ships at sea, or act as lanterns for certain deep sea fish. The light produced is a cold light with hardly any energy wasted as heat. The electric eel uses

enzymes for attack or self defence. About three fourths of the body is the electric organ which generates electricity with its remarkable enzyme system. The electric eel can discharge several hundred volts over and over again to incapacitate its prey or enemy. The venom of snakes contain enzymes which cause disintegration of the red blood cells and also clumping of red cells together. Both these effects can prove fatal. Some bacteria possess an enzyme called "invasin" which they use as a battering ram. The enzyme helps to dissolve the protective surface coatings of the victim. Invasin is also believed to be responsible for the penetrative power of the sperm cell during fertilisation of the ovum. A deficiency of invasin is probably responsible for one type of sterility.

REGULATION OF ENZYME ACTIVITY

As knowledge about metabolic pathways and the enzymes concerned accumulated during the first half of this century, biologists became increasingly disturbed by a further type of question which repeatedly presented itself. How is the complex machinery of the cell regulated? Given an adequate supply of oxygen and nutrients what prevents a cell from running continuously at full throttle?

In recent years evidence for an extremely delicate and flexible regulation of metabolic activity has been accumulating. Examples of such a control are the remarkable properties of variability and adaptiveness shown by many types of cells to changes in their environment. Micro organisms in particular exhibit a high degree of metabolic versatility. Two distinct types of regulatory mechanism are known by which the necessary degree of control is achieved.

1. Control of enzyme synthesis
2. Control of enzyme activity.

If the amino acid L-threonine is added to the growth medium of *E.coli*, the bacterium converts the threonine into the amino acid L-isoleucine essential for the synthesis of the bacterial proteins. Would the bacterial cells continue to synthesize L-isoleucine if the growth medium had already more than enough of it for making the bacterial proteins? The answer was—No. When isoleucine was in excess the bacterial cells ceased to produce it. When the level fell below a certain value the cells started producing isoleucine again. Like the temperature level in a house with a thermostatically controlled heating system the level of isoleucine in the cell exerts negative feed back control on its production. Umbarger (1961) showed that this control was exerted in two ways.

1. Inhibition of the enzyme threonine deaminase catalysing the first step in the synthesis of isoleucine.
2. Stopping production by the cell of all the enzymes required in the metabolic pathway.

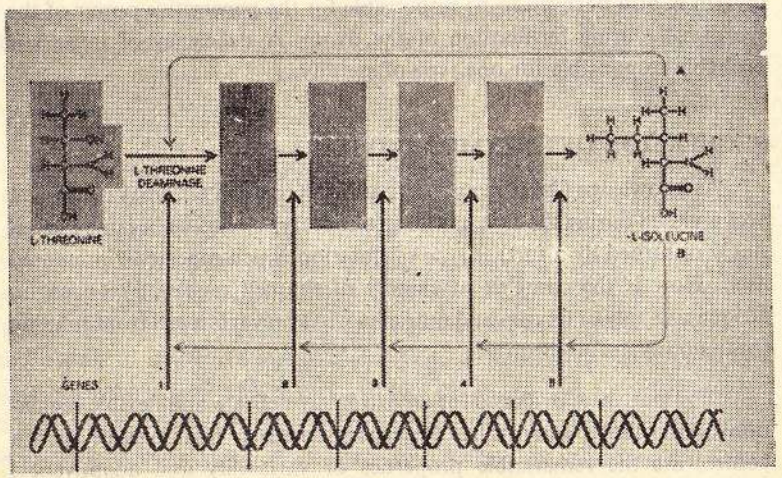


Fig. III

TWO FEEDBACK SYSTEMS control the biosynthesis of cell products, as shown here for the synthesis of the amino acid L-iso leucine in the bacterium *Escherichia coli*. The end product of the synthesizing chain acts as a regulatory signal that inhibits the activity of the first enzyme in the chain, L-threonine deaminase (A), and also represses the synthesis of all the enzymes (B).

They obtained two mutant strains of *E.coli*. One of them had lost the ability to inhibit threonine deaminase in the presence of excess isoleucine while the other mutant strain had lost the ability to halt the production of enzymes needed for isoleucine biosynthesis. Clearly the two mechanisms of control are different.

Control of enzyme synthesis

Repression of enzyme synthesis is observed with anabolic enzymes concerned with the synthesis of cellular components. In the many microbial systems studied including those that lead to the biosynthesis of the amino acids tryptophan, histidine and arginine, the presence of the amino acid

serves as a signal that the enzymes leading to its synthesis are not required. With catabolic enzymes, concerned with the degradation of food, the response is positive. There is enzyme induction instead of repression. The best studied system is the lactose system of *E.coli.* Jacob and Monod (1961) showed that the synthesis of three enzymes required in successive steps for the utilization of lactose is induced by lactose itself. They found evidence for two different kinds of genes—"structural genes" controlling the sequence of amino acids in the enzyme molecules and "regulator" genes that control the rate of synthesis of enzymes.

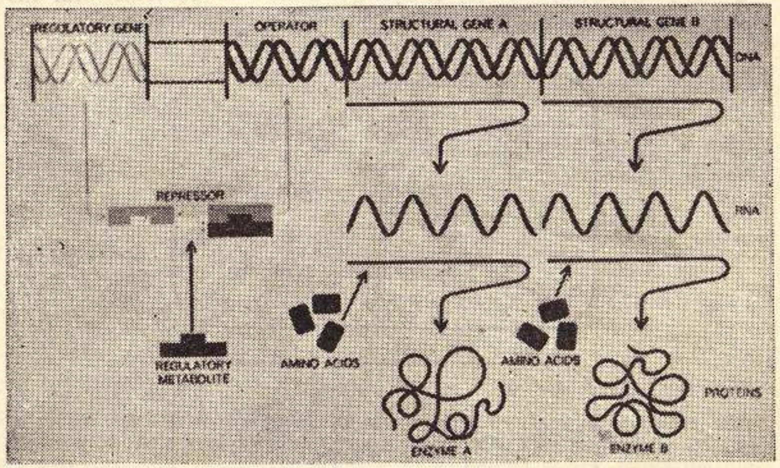


Fig. IV

CONTROL OF PROTEIN SYNTHESIS by a genetic "repressor" was proposed by Francois Jacob and Jacques Monod. A regulatory gene directs the synthesis of a molecule, the repressor, that binds a metabolite acting as a regulatory signal. This binding either activates or inactivates the repressor, depending on whether the system is "repressible" or "inducible". In its active state the repressor binds the genetic "operator," thereby causing it to switch off the structural genes that direct the synthesis of the enzymes.

How does the regulatory gene work? Genetic experiments suggested that the regulator gene is responsible for the synthesis of a repressor molecule which controls the functioning of the structural genes. The repressor molecule does not act on the structural genes directly. It binds itself to a special structure on the chromosomes that is closely linked with the structural genes for the enzymes involved. This special genetic structure is called the "operator gene". Although the repressor molecule has never actually been isolated, recent evidence suggests that it must be protein in nature. The binding of the repressor to the operator gene causes the latter to switch off the activity of the adjacent structural genes thus blocking the synthesis of the enzyme molecules.

This scheme of control applies to both "induction" and "repression" of enzyme synthesis. In repression the regulatory signal—say tryptophan or isoleucine—combines with the repressor molecule and activates it. The activated repressor molecule combines with the operator gene causing repression of enzyme synthesis. In induction, on the other hand, while the repressor by itself is able to bind with the operator gene, the repressor—regulator signal (say lactose) complex is unable to combine with the operator gene. Thus the cell machinery is free to synthesize the enzymes.

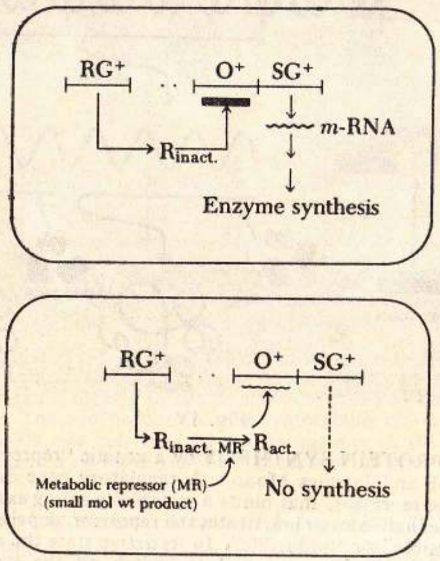


Fig. V

Postulated mechanism of repression. In the top drawing, RG^+ forms a repressor which is inactive and which cannot block m-RNA synthesis. In the lower sketch, introduction of the metabolic repressor (MR) activates R_{inact} R_{act} which can now combine with O^+ to block m-RNA synthesis and thereby repress protein synthesis.

The repressors in the cell must therefore be specialized receptors, each capable of recognising a specific signal. Sometimes "regulatory signals" resembling the genuine signals trick the cell machinery into either producing enzymes or inhibiting their production. It is like tricking a

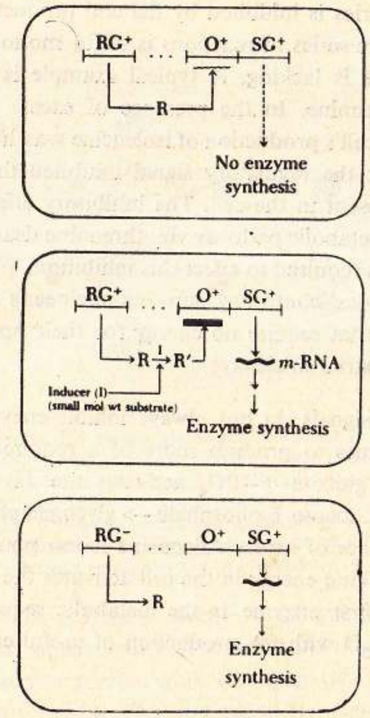


Fig. VI

Postulated mechanism for induction and constitutive enzyme synthesis. The top sketch shows a wild-type cell. R synthesized by RG^+ attaches to O^+ and prevents formation of m-RNA by SG^+. The middle sketch shows that, in presence of inducer (I), R—> R′, which is inactive and cannot combine with O^+ to block SG^+ synthesis of m-RNA. Therefore m-RNA is formed and in turn controls synthesis of specific protein. In the third sketch, inactivation of RG^+—> RG–by mutation prevents formation of R, and thus uncontrolled or constitutive synthesis of enzyme protein occurs.

slot machine to work by a false coin. The synthesis of tryptophan is suppressed by the presence of 5-Me- tryptophan in the growth medium of *E.coli.* Since the cell cannot synthesise its proteins in the absence of one of its essential amino acids tryptophan, the cell stops growing and dies of starvation. The false signal in effect acts as an antibiotic in this case.

Control of enzyme activity

Metabolites such as amino acids or nucleotides are synthesized by the bacterial cell in a series of separate steps, each step being catalysed by a different enzyme. It is often found that the catalytic activity of the first enzyme in such a series is inhibited by the end product of the last step. In this way the entire series of reactions is set in motion only when the particular metabolite is lacking. A typical example is the synthesis of isoleucine from threonine. In the presence of excess isoleucine in the growth medium the cell's production of isoleucine was halted *immediately* —which means that the regulatory signal inhibited the activity of the enzymes *already* present in the cell. The inhibitory effect is only on the first enzyme in the metabolic pathway viz: threonine deaminase. Furthermore, no energy was required to effect this inhibition. We find here a very efficient and economical control system—an engineer's dream—a factory with control relays that require no energy for their operation would be the last word in industrial efficiency!

The regulatory signals do not always inhibit enzymes. They sometimes activate enzymes to produce more of a required substance. The presence of excess glucose–6–PO_4 activates the last enzyme in the metabolic sequence Glucose-6-phosphate—> glycogen promoting glycogen synthesis. The presence of excess Adenosine mono phosphate—a sign of the low level of working energy in the cell activates the enzyme glycogen phosphorylase the first enzyme in the metabolic sequence glycogen—> glucose—> $CO_2 + H_2O$ with the production of useful energy in the form of A.T.P.

The cell possesses two types of control of enzyme activity—negative (inhibited enzymes) and positive (activated enzymes). There are situations when both types operate simultaneously.

How do the regulatory signals work? The signals-either activators or inhibitors—are usually small molecules and the receptor is a regulatory enzyme. How does the enzyme translate and integrate the signals it receives? A molecule can recognize a message only in terms of geometry. i.e., the shape or configuration of the molecule bearing the message. In this case the message is supposed to cause the enzyme to carry out or refrain from carrying out a certain reaction viz. conversion of a specific substance into a specific product. The molecule bearing the message has often no structural resemblance to the substrate or the product. How then does the signal interfere with the enzyme's performance of its specific catalytic action on the substrate?

Monod and his colleagues (1965) have developed a hypothesis which seems to explain satisfactorily the observed facts. They postulate that

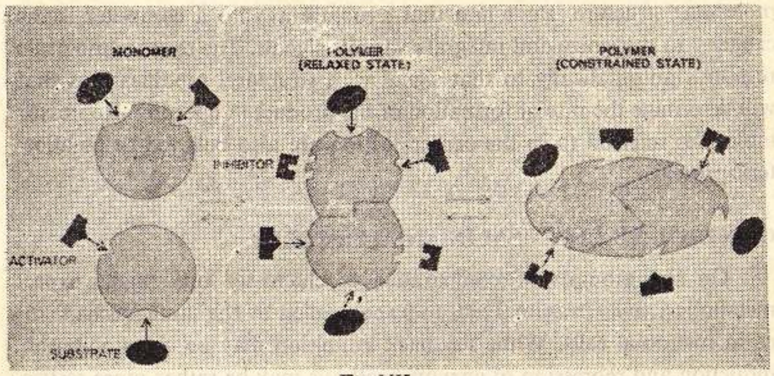


Fig. VII

REGULATORY CHANGES in an allosteric molecule are conceived of as arising from its shifting back and forth between two states. The polymeric molecule is made up of several monomers (two in this case), as shown at left. The polymer can exist in a "relaxed" state (middle) or a "constrained" state (right). In one condition it binds substrate and activators; in the other state it binds inhibitors. The binding of a signal tilts the balance toward one or the other state but the molecule's symmetry is preserved.

regulatory enzymes are polymers composed of identical subunits and having a definite axis of symmetry. The substrate attaches itself at one binding site on the enzyme protein while the signal (activator or inhibitor) attaches itself at another site. The binding of the signal on the protein molecule alters the conformation of the active site for the substrate molecule in such a way that when the signal is an inhibitor, substrate binding is prevented (an antagonistic effect) and when the signal is an activator, substrate binding is enhanced (a co-operative effect). Such proteins are called allosteric proteins. The allosteric protein is assumed to switch back and forth between two states. In each state the symmetry is maintained. The two symmetrical states differ in the energy of binding between the subunits. In the more relaxed state, the enzyme molecule will preferentially bind activator and hence the substrate. In the more constrained state it will bind inhibitor. Whichever compound it binds (activator or inhibitor) will tip the balance so that it favours binding of that category of small molecules. A change in the relative amounts of substrate and signal may tip the balance one way or the other. This model explains how the enzyme molecule's binding sites may interact either cooperatively or antagonistically. It also suggests how an enzyme may integrate different messages simply by adopting a characteristic state of spontaneous equilibrium between the two states. The powers of control and regulation of the regulatory enzymes depend entirely therefore on the form of their molecular structure. Built into that structure as into a computer is the capacity to recognize and integrate various signals. The enzyme molecule responds automatically to that signal with structural modifications that will determine the rate of formation of the product in question. Repressor molecules referred to in the earlier section are also believed to be allosteric proteins.

CONTROL MECHANISM IN ANIMAL CELLS

On the grounds of comparative biochemistry one might expect metabolic activity in animal cells to be controlled by the same mechanisms as in microbial cells. While feedback inhibition may be quite common, induction and repression of enzyme synthesis may be rather more restricted in view of the fact that the nutritional environment of and the metabolic demands upon most types of cells do not vary as in the case of microbial cells. Both feedback inhibition and repression of enzyme synthesis have been reported in animal cells. Interest in this phenomenon in animal cells arises from the fact that these mechanisms or similar ones may play a significant role in the process of differentiation and embryogenesis. Attempts have been made to explain malignancy in terms of abnormal cell control mechanisms which result in altered control of DNA synthesis and unrestricted cell division. One human disease at least—the Adrenol genital syndrome—has been attributed to the failure of a feedback contro-mechanism.

From the point of view of the molecular biologist much current interest centres around the occurrence and properties of allosteric proteins, repressor molecules and regulatory enzymes. Enough has been said to impress on you the central role that enzymes play in life. The Nobel Laureate, Professor Linus Pauling, has aptly remarked:—

"When we understand enzymes, their structure, the mechanism of their synthesis, the mechanism of their action.....we shall understand life...except for those aspects of life that involve mental processes and I have no doubt that enzymes are important for these too".

References

Jacob, F. and Monod, J. (1961). Genetic regulatory mechanisms in the Synthesis of Proteins. *J. molec. Biol.*, 3, 318.

Monod, J., Wyman, J. and Changeux J—P (1965). On the Nature of Allosteric Transitions: A Plausible Model. *J. molec. Biol.*, 12, 88.

Umbarger, H.E. (1961). Feedback control by endproduct inhibition. *Cold Spr. Harb. Symp. quant, Biol.*, 26, 301.

SECTION F—SOCIAL SCIENCES

Presidential Address

SOME CONCEPTUAL ANALYSES relevant in EDUCATIONAL ADMINISTRATION AND MANAGEMENT

by

Jinapala Alles

1.0: INTRODUCTORY COMMENT

Society, today, is in a state of unrest, oftimes approximating to turmoil, and it is continuously undergoing a process of rapid change. This process of change touches all aspects of life and is affecting major areas of personal and social living. Peoples all over the world appear to be affected in essentially the same way. The particular form which the change takes in one particular context of time and place is different especially if one examines only superficially; but, the common elements are many.

There are many different attitudes towards change—some positive and some negative. It is asserted oftimes, perhaps in moment of despair, that the change is one of degeneration and decay, leading to extinction! A more positive attitude is also seen; and those with this more positive attitude and view see the situation as one of adaptation, growth, and development. In the main, in the sequel the implicit attitude adopted is one that is essentially positive and optimistic.

In view of the above state of unrest and change, many look critically at the various specialized organs of society. Among them, the school has come in for critical examination, and comment. Definitive efforts have been made to adapt this specialized organ of the community, the school system, to meeting the challenges which the general situation present. This has been attempted in this island and elsewhere in the world.

"There are many people who think that every social problem can be solved in the school, whether it is the economic situation of the country, the need to save more money, the need for road safety, the breaking up of the benches in the park, or whether it is the somewhat more complicated problem of inequality of our present social structure"

(The School Council, 1967)

The expectations of the community from the school as an organ of society is high indeed!

In the sequel, members of The Ceylon Association for the Advancement of Science are invited to pause to consider the nature of this crisis in education and educational design. As a student of science, one would confidently suggest that in the recognition of the nature of the problem itself, and perhaps in the seeking of alternative lines of solution to it, some of the techniques and methods of the scientist have deep relevance and value. It is clear that systematic analysis of one type and another is definitively valuable. Examples of such emperical studies which seek to describe the situation are many, (Alles, 1966, 1967; UNESCO, 1968). While accepting that data gathering and data organization is specifically important in the recognition and formulation of the problem, the primary concern of the present address is the delineation of the exceptionally valuable role of conceptual theoretical analysis. It is argued that even, in seeking data, the task of collection, analysis and organisation of the data, the tasks themselves will be greatly facilitated, if it is illuminated by rational conceptual analysis. In principle, it is always much more fruitful to look *for* data than look *at* the situation without definite guiding factors and conceptual structures in mind (Larrabee, 1945).

The assertions made earlier as to the nature of the educational situation is one that is essentially world-wide (UNESCO, 1965). This is illustrated clearly by many recent studies and conferences publications (UNESCO, 1965). In particular a recent presentation (Coombs, 1967) on- -

"The World Educational Crisis—A Systems Analysis"
—is relevant and the following comment in it is noteworthy:

"It is true that national educational systems have always seemed tied to a life of crises. They have periodically known shortages of funds, teachers, class rooms, teaching materials—shortages of everything except students. It is also true, that the systems have some

how either managed to overcome their chronic difficulties, or learned how to live with them. The present crisis, however, differs profoundly from all that has been commonplace in the past. It is a world educational crisis—more subtle and less graphic than a "food crisis", or a "military crisis"—but no less real and sweeping in its dangerous potentials".

In analysing the nature of the crisis in education, it is argued that the causes of the crisis are many and these relate to resource scarcities, inertia of educational systems and the inability of societies themselves to adapt to education.

Sometimes, it is argued that the problems are essentially one of lack of finances and material resources *only*. This is perhaps a result of superficial analysis and is likely to be an uncritical comment. **Educational systems perhaps need above all that which money alone cannot buy, namely, new concepts, a willingness to analyse and use such concepts, and a continuing confidence that the situation, though one of extreme complexity is one that will yield to rational sustained directed human effort.**

Referring to the nature of the situation, the above study (Coombs, 1967) proceeds to comment as follows: "Indeed, one must note an ironic fact about the worldwide educational crisis. It is that, although the crisis has occurred amid a universal expansion in knowledge, education, as the prime creator and purveyor of knowledge, has generally failed to apply to its own inner life, the function it performs in society at large. It has failed to infuse into the teaching profession, for transmittal into the classroom, the new knowledge that is both available and is needed if the present disparity between educational supply and the demand is to be corrected. Education thus places itself in an ambiguous moral position—it exhorts everyone else to amend their ways, yet seems stubbornly resistant to innovation in its own affairs".

The purpose of the present study is essentially that of focussing the attention of students of the sciences on the role that scientific conceptual analysis can play in relation to the formulation of the problems concerning the present situation in education, the recognition of the possible alternative solutions that are relevant.

In this address, the author, as a student of science attempting educational administration and management, would raise the following questions and suggests that significant conceptual analyses can contribute positively towards development and growth:—

1. How relevant and useful are the methods of the scientist in a field such as educational development and management where a multiplicity of sociological and economic pressures of various kinds operate?

2. Is it possible to develop further the practice of educational administration and management so that it becomes increasingly able to exploit emerging concepts in systematic management practices to the solution of problems within the educational system?

3. In seeking to do the above, is it possible to proceed to act in such a way that progressively and continuously educational administrators and managers become increasingly more and more adequate as professionals?

4. Can the conceptual analyses of an educational system, as a dynamic system, assist in the solutions of problems relating to the improvement of the "productivity" of education?

It is argued that all of these are possible and indeed conceptual analyses need to be attempted if survival is to be achieved with adequacy.

2.0: A STRUCTURAL AND FUNCTIONAL ANALYSIS OF AN EDUCATIONAL SYSTEM RELEVANT IN EDUCATIONAL ADMINISTRATION

In this part of the address an attempt is made to present for critical study by students of the Social Sciences—a way of thinking—a "mental scaffolding"—that may be helpful in seeing in a useful perspective specific problems and issues in relation to school organisation and administration.

As has been stated, the "School" function essentially as a specialized organ of the community. The "school system" functions in the same way in relation to the larger community complex—the nation. Education is a major tool which each society uses to foster its ideals and attitudes, and to mould its young into the society's pattern of behaviour. An educational system finds its major direction from the culture it serves. Education, for example, in Ceylon, is a major social institution with a long history, integrated firmly within the national culture.

The evolution of institutes and other specialised organs, such as the school, in any society, occurs in response to demands for services that cannot be met by a single individual or single family unit. The institutions may be established by those who recognise the needs and who see the benefits of the services; or they may be provided by the State because the interests of the people, in the long run, make such specialised organisational action imperative.

> "Man is intent on drawing himself into a web of collectivised patterns. Modern man has learned to accommodate himself to a world increasingly organised. The trend toward evermore explicit and consciously drawn relationship is profound and sweeping; it is marked by depth, no less than by extension".

The above quotation (Schelender, Scott and Filley, 1965) summarises the pervasive nature of organisations.

As people get together for work, for fellowship, or because of geographical reasons, the necessity for collective action becomes progressively more compelling. Each specialized service provided, in general, tends to create other essential supportive additional services, thus making for greater complexity.

Some of the reasons for this heightened organisational activity in today's world may be found in the fundamental transition which has affected human society by changing it from a rural cultural to a rural-urban culture based on science and technology. These changes have brought in a way of life characterised by proximity and intimate interdependance of people.

The school system in Ceylon is a complex entity involving thousands of schools, tens of thousands of teachers and non-teachers and several million pupils. All these individuals constitute a large organisation with explicit and implicit aims and purposes. These aims and purposes can be stated in general terms; they can also be stated in specific terms. Furthermore, both at the level of generality and specificity, the aims can be stated as seen by the various participants involved in the school system. The aims and purposes may be viewed in the context of the socio-economic growth of the community and the nation. The aims and purposes may be viewed as seen by the adult individual in the community. The aims and purposes may be viewed from the perspective of the pupil who is learning within the school system and who forms the focus of attention. Further for particular purpose, such as curriculum planning, the aims and purposes can be analysed in specialised ways; and for other purposes, such as the evaluation of learning, the aims and purposes can be analysed using other theoretical analytical frameworks (Alles, 1967; Bloom, 1956).

In this address, itself, the aims and purposes, though fundamentally important, will not be discussed in detail. It will suffice to state in this context that the aims and purposes should be seen in all these varying ways and at several levels of generality and specificity by the participants if adequacy is to be achieved, at the operational levels, in an education system.

Pupils, teachers, principals, field supervisory staff, directorate staff, and policy decision-makers in education, all, form a large organisation—the educational system. This institution has many of the significant characteristics of other human institutions and the following quotation (Ross, 1958) high-lights one very salient feature:—

"The institutions of men are never static; be it state, corporation, newspaper, social club, or school. The very nature of the institution, and the people collectively identified with it, is such as to establish the truism that no man, or association of men, is precisely the same today as yesterday.

"Furthermore, should a gyroscopic device be developed to ensure consistency through the years, the organism would soon get out of step with the human milieu in which it operates. New needs emerge, old needs are satisfied or disappear. New tools are forged; new inventions are made; new vistas of knowledge are uncovered by the passage of events.

"Since an institution of man cannot remain for every unchanging in an unchanging world, the alternative to growth is decay.

"Schools are no exception to the generalisation. They must comply with the law of dynamic survival. The social setting of schools evolve; therefore, so must the schools".

Fundamental to the theory of evolution is the concept of assimilation and adaptation. Developmental progress can only be conceived in terms of the progressively successful adjustment of the organism to its environment. In a context such as above, the educators and educational administrators need to explore the nature of the adaptations which are necessary for the significant continuation of educational institutions.

All the varied participants—pupils, teachers, principals, field supervisory staff, directional staff, policy decision-makers involved in the educational enterprise are active participants in this process of growth, adaptation, and change. The adequacy with which a particular individual will function within this large system will, among other things, depend to a major extent on his awareness of his role in terms of the total enterprise. While short-term achievements may sometimes be possible without such awareness of the purpose by the participants within it, long-term adaptive growth with sustained adequacy is unlikely to be achieved without such awareness.

Sometimes a single individual may be performing many roles within the enterprise. The ability to recognise the inter-relationship of these many roles is particularly significant, in terms of professional and institutional growth. In so far as the entire enterprise depends on the teamwork of a large number of participants, it is critically important for each one to recognise the inter-dependent nature of their many roles. The coordination and team work so essential to success can only be achieved by each member of the system recognising, in an appropriate perspective, the roles of the other participants in the enterprise and in the organisations.

The conceptual study under consideration seeks to provide some guidelines that may be helpful in achieving an integrated perspective. The extent to which these guidelines will help a given individual to achieve adequacy in his role, or roles, will depend on the frequency and intensity with which the conceptual framework is used by him. These guidelines are likely to be specifically relevant to those functioning at the level of direction and supervision within the school system.

The guidelines presented in this paper have also another aspect of relevance. The current education scene is such that it calls for new methods of communication within the education service, and between the service and its consumers. These guidelines also seek to provide concepts which will facilitate such communication. It is argued that a continuous dialogue should be pursued if adaptive growth and change are to be achieved efficiently and rapidly.

The aspects of the situation which call for a new level of adequacy in communication within the educational service are implied (Department of Education and Science, 1966) very aptly in the following:—

"There have been periods in the development of education when little has changed over a long time. We do not live in such a period

The education service today is in the grip of three considerable forces, each one of which could work a transformation. There is first the sheer growth in numbers to be educated, a consequence partly of a higher birth rate and partly of the keener appetite for what education may confer. There are secondly the pressures on the education service from the society of which it is an increasingly expensive member, presures of a social, economic and technological kind. There are thirdly changes in the content and method of education as knowledge accumulates at and accelerating pace and new ranges of skill and mechanical assistance are offered to the teaching profession".

Questions can be raised as to the usefulness of frameworks of thinking such as are considered here. No attempt will be made to present a coherent argument in relation to such questions but the points of view presented in the sequel are relevant to building such an argument.

The manner in which a systematic framework of analysis can be used by a practitioner is described in the following quotation. (Dewey, 1929):

"The practitioner who knows a system is evidently in possession of a powerful instrument for observing and interpreting what goes on before him. This intellectual tool affects his attitude and modes of response in what he does. Because the range of understanding is deepened and widened, he can take into account remote consequences which were originally hidden from view and hence ignored in his actions. Greater continuity is introduced. He does not isolate situations and view them in separation as he was compelled to do when ignorant of connecting principles. At the same time, his practical dealings become flexible. Seeing more reactions he sees more possibilities, more opportunities. He is emancipated from the need of following tradition and special precedence. The ability to judge being enriched he has a wider range of alternatives to select from in dealing with individual situations".

In addition the practitioner has to analyse problems and also subject his own behaviour, and the practical action of others, to critical review. In "Adventures of Ideas" Whitehead remarks (Alles, 1961) that:

"Such criticism (of the activities of a profession) must be founded upon some understanding of the nature of the things involved in these activities, so that the results of the actions can be foreseen. Thus foresight based upon theory and understanding of the nature of things is essential to a professional".

It is postulated that the use of schemes such as indicated in the current address may in fact enable the educational administrator to function at the level of a professional rather than at the level of a routine technician.

In the analysis of problems and decision making one has to carefully select the relevant facts. It is important to note, however, that (Larrabee, 1945):

"Relevant facts do not label themselves as relevant. That is an element which must be added by the knower. Unless he is a mere random collector of odds and ends, the seeker of knowledge cannot go through life merely looking at things; he must be looking for something; that means active inquiry with some directing factor in control".

The present exercise is an attempt to provide the educational administrator with a useful organized complex of directing factors. It is described in outline below:—

AN ANALYSIS OF STRUCTURAL AND FUNCTIONAL ASPECTS OF AN EDUCATIONAL SYSTEM

The educational system is a complex, highly organised entity. The definition and description of such a system present many problems. The analysis of such a system, from a structural and functional standpoint, presents a particularly difficult task.

Analytical techniques always do some violence to the system, or process being analysed; and even a simple classification is an attempt at ordering on the basis of analysis and abstraction; and hence it may do some violence to the system as observed under normal conditions. Nevertheless, the attempt to analyse discriminately is often of great value. In particular, such analyses can provide for greater control of the phenomenon, process, or system; and may even provide greater insight. To this extent such analyses have practical value.

An attempt is here made to isolate certain significant "elements" of the system. Thereafter the major "unit processess", "unit operations" and a "schematic model" will be presented which will indicate in outline a significant pattern of function and articulation of various levels of operation within an educational system.

It is significant to note that the analysis here attempted is a general framework applicable to *any* complex organised system such as the one described.

THE PRINCIPAL ELEMENTS CONSTITUTING THE EDUCATIONAL SYSTEM

In general, the management and administration of any project may be defined as a process of co-ordinating available resources to achieve economic, political, social and other objectives within the framework of specified policy. In a sense, when viewed at a high level of generality, the major elements of a system such as the educational system are—

1. Policy.
2. Resources.
3. Execution.

Policy may be explicit or implicit in the following:

General and specific legislative provision.
General analyses made by National Commissions.
Classical Studies.
Long and short term perspective plans and programmes.

Resources are, in the main, three-fold, and are as follows:

(i) Human resources
(ii) Material and financial resources
(iii) Time, as a resource.

No comments will be made in relation to the first two types of resources except to note that the education system itself may be looked upon as a human resource development programme. It is important to note that time is also a critical resource in terms, specially, of developing countries. Time is particularly important in an enterprise such as education where the results of action are seen after a considerable lapse of time.

Execution is the means by which policy and resources inter-act under appropriate conditions to yield the specified objectives. Further comment will be made later relating to this "interaction element".

The magnitude and the pattern of distribution of resources are themselves significant. The magnitude may entail "Intertia" type properties in the system. The pattern of distribution may entail "entropy" type properties in the system. The pattern of distribution if it entails "entropy" type properties, may imply limitations on "availability" of resources.

THE PRINCIPAL "LEVELS" OF OPERATION AND EXECUTION WITHIN THE SYSTEM.

The analysis of the system into the three principal elements is, to some extent, a static view of the system. In order to be usable, it needs to be supported by further extended analyses.

An extended analytical view of the educational system may be achieved as follows:—

One can view the total educational system as a very large complex organised process with—

(i) A series of LEVELS of operation and execution
(ii) Each level of operation having a series of UNIT PROCESSES AND UNIT OPERATIONS, associated with it.

In the sequel the series of "Levels" of operation will be described in outline.

It will be recognised that the basic level of operation, and the most fundamental one in relation to the educational system, is the class-room level with the teacher, the other participants being the pupils. This particular level will be referred to as:

LEVEL I: TEACHER-PUPIL LEVEL—(L-I)

The teacher and the pupil are the two principal actors as far as school education is concerned. The entire educational system, all its levels, all its resources and modes of interaction and function, are directed towards this common purpose that of facilitating learning by pupils in the classroom.

The next level is that related to the principal and the teachers. The principal is the leader at this level. This level will be referred to as:

LEVEL II: THE PRINCIPAL-TEACHER LEVEL (L—II)

In terms of the education system, another useful organic unit to consider is the school. This level, L—II, corresponds to "The School".

The next level is that in which the field supervisory staff and the principals are involved. It will be referred to in this study as:

LEVEL III: THE FIELD SUPERVISORY STAFF-PRINCIPAL LEVEL—(L—III)

The next Level corresponds to the level of Regional Direction and involves the Directorate and the Field Supervisory Staff. This Level will be designated as:

LEVEL IV: DIRECTION-FIELD-SUPERVISORY STAFF LEVEL—(L—IV)

The last level is that corresponding to the Ministry of Education, the Director-General and the Directorate. This level will be designated as:

LEVEL V: MINISTRY-DIRECTORATE LEVEL—(L—V)

It will be observed that Level I is the basic operational level within the educational system; and Level V is the policy decision-making level in the educational system. Level V along with Level IV is involved in interpreting policy to particular levels of education. Level III and Level II are directly and intimately involved with the operational level in the school and in the class-room. At Level II and Level III the individual communities are intimately associated. At Level IV and Level V the larger unit—the region and the nation, —are involved. All these levels need to work in harmony and when they do so the system operates with adequacy.

In terms of the society and culture in Ceylon, the formal assertion of the general goals of the educational system are made through the established organs of democracy, namely Parliament, through the Ministry of Education, at Level V. Broad policy decision relating to education made by the representatives of the people finds executive action through the Ministry of Education, via. Levels IV, III, II and I, in that order. The final implementation of these policies are realised in the multitude of heterogeneous educational institutes—primary schools, secondary schools, universities, technical institutes etc. etc. All the levels ultimately justify their existence only in so far as they support and actively stimulate Level I to operate with adequacy.

THE PRINCIPAL "UNIT PROCESSES" AND "UNIT OPERATIONS" ASSOCIATED WITH EACH LEVEL.

Further insight into the system is achieved by seeking to isolate the basic "processes" which the operators at the various levels use to achieve the desired ends.

In this analysis it is postulated that each level of operation has associated with it a series of significant "unit processes". Those operating at a given level use these unit processes to order the various resources available to achieve given ends.

As a matter of convention Levels V, IV, III, II are described as levels at which "administration and management" tasks are carried out. Level I itself is usually not so described. Level II is said to involve "administration" as well as "teaching". This view point, in general, has some validity. In this analysis it is postulated that—

(i) Notwithstanding the difference in the levels and the nature of the assignment, at each of these levels the major "unit processes" used to order means to ends remain essentially the same.

(ii) The major "unit processes" that may be said to operate at each of these levels may be described briefly by the following terms:

1.0 : Decision-making
2.0 : Planning
3.0 : Communication and Execution
4.0 : Assistance, guidance and supervision
5.0 : Evaluation and assessment.

Ideally these major unit processes may be considered as quite distinct and separate; and may be assumed to occur cyclically. In practice, this is not always the case and it is not always that they are followed in this sequence. The terms used to describe the unit processes are more or less self-explanatory; but some notes may be useful.

1.0 and 2.0 : *DECISION MAKING AND PLANNING.*

In general these two unit processes are best considered as two intimately connected unit processes involve essentially a process of preparing a set of decisions for action in the future. These two unit processes together involve the person operating on it to work-out a set of decisions which may be described as a matrix of interdependent decisions. Often they also constitute a sequential series of systematically related decisions.

"The World Year Book of Education, 1967—Educational Planning" (Bereday, Lanwerys and Blaug, 1967) referring to definitions of "Educational Planning", asserts:

"There are several key elements common to these and other serviceable formulations.

1. They specify orientation to the future.
2. There is the orientation to action (rather than to such other aims as acquiring knowledge or communicating information).
3. The definitions imply preparing or designing of something and therefore, are in some degree concerned with deliberative endeavours . . . .

"The orientation to action implies that decision makers and planners presume that their plans will be passed upon, and if approved, implemented. However, implementation is not part of planning itself . . . . Planning is substantially and in most cases formally and legally a process of preparing a set of decisions to be approved and executed by some other organ. Even if the same unit combines planning functions with authority to approve and executive, these are distinct, though interdependent, processes which must be kept analytically separate".

In this address no attempt will be made to elaborate on either decision-making or planning. The techniques and methodologies that are available are many and varied. The most appropriate reference is, in fact, Chapter I, The World Year Book of Education, 1967, titled "Theoretical Considerations in Educational Planning".

In considering these unit processes it is important to recognise that planning may involve among other things the following aspects:

(i) Schools—their organisation and administration.

(ii) Curriculum—its analysis, assessment and reconstruction.

3.0: COMMUNICATION AND EXECUTION

This major unit process involves the communication of plans and other inter-related aspect of execution and management.

This may involve any or all of the following:

Communication of plans to different levels of execution;

Communication relating to organisation and administration of schools;

Communication relating to organisation and imparting of instruction.

e.g. To functional levels of schools:

Schemes of instruction.

Outlines of procedure for the evolution of such schemes.

Outlines of significant principles basic to their design.

To teacher—education levels:

Teacher education (Pre-Service)

Teacher education (In-Service).

4.0: ASSISTANCE, GUIDANCE AND SUPERVISION

A communication invariably needs further interpretation and extrapolation. "noise" and "ambiguity" are present more or less in all communications. Furthermoie those charged with the transformation of the communication into action may need assistance and guidance. Quality performance may demand supervision. These aspects may refer to routine administrative processes in a school or it may refer to the organisation and administration of the instructional programme in all its aspects.

5.0: EVALUATION AND ASSESSMENT

Implementation of a project must necessarily entail at some point of time, evaluation and assessment. Such evaluation and assessment will be carried out in terms of the objectives set out in relation to the project.

Assessment and evaluation are essential because without the operation of this unit process there would be no evidence as to whether the project is moving towards the achievement of the targets set out. No detailed analysis of this unit process will be attempted. Nevertheless in relation to this unit process the following principles of action may be useful:

1. Evaluation and assessment should preferably be process—or project-oriented (not oriented to the assessment of individuals *per se*).
2. The evaluation and assessment should seek to obtain valid, reliable data and should seek to achieve quantitative indices of performance where this is possible.
3. The evaluation and assessment and in particular the quantification of it, should not necessarily imply the discarding of judgement. The systematic procedure should seek to get additional data so that judgement can be exercised with awareness.

4. The incidence of assessment and evaluation should be kept to the minimum consistent with need to follow up, obtain adequate feed back information, for adaptive control and change.
5. Assessment should consider both short and long term ends.

The five major unit processes, it is postulated occur at all the varying levels, from Level V. The difference essentially is in relation to the "raw material" on which the process operates and the "fine structure" associated with the level.

Each of these major "unit processes" may be further sub-divided into an appropriate series of "unit operations". In this address no attempt will be made to analyse all of them in detail. The "unit process" related to decision-making and planning alone will be analysed.

Ideally the unit processes of decision-making and planning may be considered to involve the following set of unit operations:

1. Analysis of the "present" situation, including collection, and classification of data relevant to the situation.
2. Formulation of problems that are significant to the execution of the project and relating to the present situation.
3. Postulation of alternative tentative solutions.
4. The analysis of the alternative solutions using appropriate criteria.
5. The choice of a preferred solution and an adequate course of action.

These "unit operations" depending on the level and the nature of the issue, may have a great deal of "fine structure".

To recognise the above fact more particularly one may consider decision-making and planning at level V, that is, at the Ministry-Directorate Level. At this level, the situation that is analysed will relate to the entire educational system and will be concerned with the nation and its development as a whole. The analysis of the data swill be carried out in such a way as to be suitable for study at the national level by policy decision-makers. The extent of detail will, therefore, be kept to the relevant level and it may be necessary only to show significant regional differences and broad trends.

Similarly, the problems will be formulated so that they help in the recognition of relevant policy. The alternative tentative solutions will refer to the possible alternative policy decisions available to the decision-makers. Similar comments will apply to "Unit Operations" 3 and 5 as well.

In marked contrast, if we consider Level I, that is the Teacher-Pupil Level, then the analysis of the situation will be at a very high level of detail. The teacher will need to analyse a particular classroom and, within it, he will need to consider, classify, and recognise groups of pupils who have differences in abilities and aptitudes. Likewise the types of problems that are significant at Level I are different to the types of problems that are significant at Level V. Problems at Level I are actually operational issues relating to teaching and related to specific questions such as following:

(i) What topic shall I teach the pupils this week?

(ii) What particular activities shall I use in order to present the topic during the course of the week?

(iii) What materials can I use for the activities?

(iv) How shall I pace the subject so that the pupils find it satisfactory?

(v) How shall I find out whether the pupils are actively learning?

(vi) What particular questions shall I ask to ascertain progress of learning?

(vii) What particular exercises and self-study shall I use relating to the topics?

(viii) How shall I link these topics with other activities in the curriculum? etc. etc.

The alternative solutions which the teacher will consider will be also highly operational in nature and will have concreteness and specificity.

The analysis and selections of the alternative solutions will be related and will be based on the data already obtained and similar comment will apply to Unit Operation 5.

The above comments illustrate the type of variation that is observed between Level V and Level I. It will be clear that the intermediate levels will relate to situations, problems, solutions etc. that are intermediate in terms of detail.

The "unit processes" and the "unit operations" constitute the main patterns of action which an administrator or manager uses to order means to ends.

A "SCHEMATIC MODEL" INCORPORATING THE ABOVE CONCEPTS—"LEVELS OF OPERATION", "UNIT PROCESSES" AND "UNIT OPERATIONS".

In the outline analysis presented in the preceding paragraphs the following features have been recognized in regard to the educational system.

(i) A series of "levels" of operation and execution.

(ii) A series of "unit processes" and "unit operations" are postulated to be associated with each "level" of operation.

(iii) The analysis, as indicated, implies a complex interaction pattern within the system.

The educational system is such a complex organised entity that the description of even the principal modes of interaction is not easily carried out without the use of a suitable graphic, or schematic "model".

Several types of "models" may be considered for use in this context. One that is conventionally used in such contexts is "the organisation chart", showing lines of formal communication and authority relationships within the administrative system.

In the present study, the emphasis and viewpoint is such that the technique of the organisation chart alone is inadequate. Hence, a special "schematic model" has been evolved. This is given in Chart I.

As a preliminary to a discussion of the "schematic model" in Chart I, an outline description and specification relating to "the model" is relevant (vide Chart). This is attempted in the sequel:—

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LEVE
(5 wh

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2.0 :
3.0 :
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5.0 :

1. U
2. U
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5. U

Note.

**Ada*

SCHEMATIC MODEL
OF
STRUCTURAL AND FUNCTIONAL ASPECTS
OF
AN EDUCATIONAL SYSTEM*

LEVEL I—Represents the Teacher-Pupil Level
(1 white dot)

LEVEL II—Represents the Principal-Teacher Level
(2 white dots)

LEVEL III—Represents the Field-Supervisory Staff-Principal Level
(3 white dots)

LEVEL IV—Represents the Directorate-Field-Supervisory Staff Level
(4 white dots)

LEVEL V—Represents Ministry-Directorate Level
(5 white dots)

1.0 : Unit process—Decision Making
2.0 : Unit process—Planning
3.0 : Unit process—Communication and Execution
4.0 : Unit process—Assistance, Guidance and Supervision
5.0 : Unit process—Assessment and Evaluation

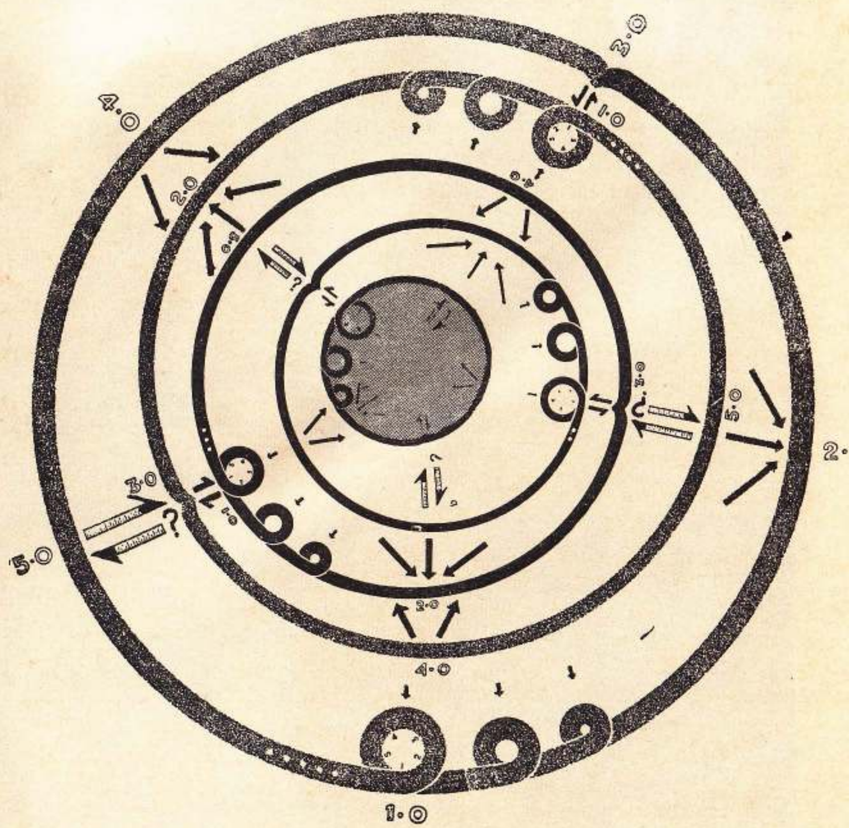
1. Unit Operation—Analysis of the "present" situation, including collection, and classification of data relevant to the situation.
2. Unit Operation—Formulation of problems that are significant to the execution of the project and relating to the present situation.
3. Unit Operation—Postulation of alternative tentative solutions.
4. Unit Operation—The analysis of the alternative solutions using appropriate criteria.
5. Unit Operation—The choice of a preferred solution and an adequate course of action.

Note.—The systems of arrows in the schematic model denote the various modes of interaction and communication within the system.

**Adapted From:* (i) E. H. Litchfield—Notes on a General Theory of Administration, Administrative Science Quarterly, Vol. I. No. 1, 1956.

(ii) Jinapala Alles & G. Zakrzewski—Proceedings of the Conference on Research for Educational Planning in Asia—Tokyo, 1963.

CHART



The levels of operation and execution referred to in the earlier analysis are represented in Chart I by a series of cyclic curves with three sub-cycles in each. In the chart of "the schematic model" there are five such cyclic curves; these cyclic curves are have located, prior to the sub-cycles in the main curve a sequence of dots. The outer-most curve is denoted by five white dots and the innermost by one. These curves with their "fields"—the area within the curve—represent the levels of operations indicated earlier:

LEVEL I (with one dot) represents The Teacher-Pupil Level.

LEVEL II (with two dots) represents The Principal-Teacher Level.

LEVEL III (with three dots) represents the The Field-Supervisory Staff—Principal Level.

LEVEL IV (with four dots) represents the Directorate-Field Supervisory Staff Level.

LEVEL V (with five dots) represents Ministry—Directorate Level.

The innermost "curve" and shaded "field" represent the class-room. As has been remarked earlier this is the most significant level of operation in the educational system. All other levels exist in order to support the activity at this level. Immediately outside this level are the two other curves drawn with bold dark lines. These represent the Principal—Teacher Level and The Field Supervisory Staff-Principal Level. In many senses these two levels are intimately associated with Level I and are specially significant and important operational levels.

The outer levels are represented by diffuse lines. These Levels IV and V, are directional, policy interpretational, and policy-making levels and are somewhat removed from immediate operational scene in a class-room.

It will be observed that in each of these curves in Chart I there are two points at which the curve is modified. One of these involves a modification of the curve into three smaller sub-cycles. In the outer most curve this point of modification is marked by the symbol "1.0". Immediately preceding this modification is the notation for designating the level (five dots).

If this curve is now followed in an anti-clockwise direction we come to a symbol "2.0", and then to a point in the curve denoted by the symbol "3.0". At this point the curve is modified to an inward directed arrow. Thereafter if the curve is followed anti-clockwise two other symbols are met with, namely "4.0" and "5.0". These number symbols are present in the curves V, IV and III. In order not to clutter up the "schematic model", the symbols "1.0", "2.0", "3.0", "4.0", "5.0" are not indicated in the two inner curves. But it is important to recognise that these stages and characteristics occur similarly in these two curves as well.

The points in these curves denoted by the symbols 1.0, 2.0, 3.0, 4.0, 5.0 represent the principal five "unit processes" as described earlier and this is indicated below:

1.0	:	Unit process-Decision making	(U.P.1.0)
2.0	:	Unit Process-Planning	(U.P.2.0)
3.0	:	Unit process-Communication and Execution	(U.P.3.0)
4.0	:	Unit process-Assistance, Guidance and Supervision	(U.P.4.0)
5.0	:	Unit process-Assessment and Evaluation	(U.P.5.0)

The above unit processes may be considered in the context of Level I. The following comments may assist in the interpretation of the analysis:

LEVEL I: TEACHER-PUPIL LEVEL

U.P. 1.0: The teacher has a Syllabus of Instruction and Schemes of Work communicated to him. He is now assigned to a particular school, to a particular class and has had indicated to him a time table of work etc., by the Principal. In the context of the resources available to him and the instructions and guidance provided by the Schemes of Work, and the Principal's own direction, the teacher decides on a theme for teaching for the class, during a specified time interval. In so doing he will need to consider not only the facilities available to him and the time available to him but also the readiness and background of the pupils and the particular problems that the pupils are likely to meet within learning the selected theme.

U.P. 2.0: In the context of the above considerations the teacher can plan out a lesson. In this lesson he will break the theme down to a series of topics and sub-topics, plan out activities which provide a preferred basis for the learning. In doing this the teacher will use his professional knowledge and skills relating to the design of lessons etc.

U.P. 3.0: The lessons having been planned, the teacher has now to go through some degree of personal preparation. This may necessitate the organising of the facilities in the class-room for the purpose of the lesson. In the simplest cases this may only relate to cleaning up of the black-board, getting the chalk, and perhaps preparing and setting up charts. In other instances, such as in science lessons or woodwork lessons the preparatory work may be very extensive. Having executed this part of the preparation, the teacher is now ready to communicate, that is, to teach the lesson and he does so.

U.P. 4.0: As soon as the teacher has proceeded to do some part of the teaching, invariably some of the activities which provide the basis for learning (and these may be done by groups of pupils) may necessitate the teacher giving assistance, guidance and supervision in the carrying out of the activity. He may also need to communicate to the pupils what the significant and relevant observations are. With such assistance, guidance, and supervision the pupils will pursue the lesson.

U.P. 5.0: At appropriate points within the lesson the teacher may need to ask suitable questions to assess whether the pupils are following the lesson. At further points of time, within the lessons itself or in subsequent lessons, the teacher may have to organise and design tests to assess pupil growth.

Note:—In the light of the information so gained it will be necessary for the teacher to proceed to further discussions relating to lessons and lesson planning. He will thus proceed to follcw the cycle of operations repeatedly till the end of the teaching programmes are achieved.

Because Level I is the most significant, the above illustrative interpretation has been provided in some significant detail for that level. A little consideration will indicate that similar comments can be made in relation to Level II, Level III, Level IV, and Level V. It is not the intention of this paper to spell out in detail the appropriate interpretations for all these levels. It is suggested that the reader may consider another level using the above guide-lines for Level I.

In the "schematic model" the inward directed arrows, on the curves at 3.0, indicate the points at which one level communicates with the other in a formal manner. It will be observed that "U.P.3.0" communicates with "U.P. 1.0" of the next "inner" level. At this point, the interaction is represented by a reversible arrow—a two way communication is postulated.

This mode of interaction and formal communication is essentially the normal line of authority as represented in a graphic organisation chart of the conventional type.

"U.P. 2.0" which precedes "U.P. 3.0" relates to planning. Three convergent arrows within the field are directed towards it.

"U.P. 1.0" is represented by three sub-cycles on the main curve and to each sub-cycle is directed a small arrow head.

Because they are functionally intimately linked, the two "unit processes" 1.0 and 2.0 may be considered together. The convergent set of arrows directed towards "U.P. 2.0" signifies the participation of those within the system in planning. It implies that those operating at a particular level specifically invite those operating in the inner levels to participate in planning. Planning is a pervasive activity occurring at all "levels" and appropriate participation is indicated in all "fields". Ideally even the pupils need to be invited to participate in the lesson planning in an appropriate way.

The three small arrow heads directed towards the sub-cycles associated with "U.P. 1.0" stand for the in-flow of information and data from the system to the decision making stage at the various levels.

On the basis of the information and data fed in at "U.P. 1.0" Decision-making, the two unit processes of decision-making and planning (which are intimately linked) are worked out with participation from the relevant inner "fields".

The unit operations (abbreviated to U.P.) within the decision-making U.P. 1.0, are designated by the symbols 1, 2, 3, 4, 5, these symbols being located within the sub-cycles. As has already been remarked they stand for the five "unit operations" within the principal "unit process" 1.0.

"U.P. 1.0"—Decision making is, ideally, made up as follows:

"U.O. 1 — Analysis of the "present" situation, including collection, and classification of data relevant to the situation.

"U.O. 2 — Formulation of problems that are significant to the execution of the project and relating to the present situation.

"U.O. 3 — Postulation of alternative tentative solutions.

"U.O. 4 — The analysis of the alternative solutions using appropriate criteria.

"U.O. 5 — The choice of a preferred solution and an adequate course of action.

In actual operation, these sequences and the pattern of interaction do not occur ideally, as described. But it is assumed that when the programmes are being executed, with reasonably high adequacy, the ideal sequences tend to be approximated to.

The three sub-cyclic sequences shown at 1.0 do not imply that only three decision making operations are carried out. In general a multiplicity of decision making sequences occur and these are continuous through "U.P. 1.0" and "U.P. 2.0". The three sub-cycle symbolize this fact.

The out-comes of the "U.P. 1.0" and "U.P. 2.0" i.e., Plans and Programmes, find approval and then application at "U.P. 3.0". This means that the plans and programmes which have been designed, approved, and accepted, are communicated, with relevant orders and instructions, for execution at the appropriate levels within the system through the channel of communication at "U.P. 3.0". The level that is originating the plans and orders will need to, itself, do some execution by way of allocation of resources, etc., to the level to which it communicates and instructs.

Through participation at "U.P. 2.0", the inner level would already be partly familiar with the plans, etc., communicated at "U.P. 3.0". But nevertheless, some assistance, guidance, supervision are required. (on account of "noise", "ambiguity", etc., in the communication). Finally assessment and evaluation will be needed. Hence, having proceeded to "U.P. 3.0", one proceeds to "U.P. 4.0" and "U.P. 5.0". The divergent arrow set and graduated double reversible arrow in the field denote these activities. The "question mark" with double arrow denotes ambiguities and interpretative problems in assessment and evaluation ("noise" and "ambiguity" in "feed-back").

Thereafter, in terms of "feed-back", new, or modified decisions (improved and adaptive), are made and the entire cycle of processes are traversed again and again in unending sequence, till the project objectives, are finally achieved (or in a continuing project, without end).

The above comments will indicate that the pattern of thinking implicit in the schematic model and outlined in this paper is a general one, and that it is applicable in all types of project implementation.

A most significant factor which is emphasized and stressed in this schematic model is the fact that passive communication does not obtain. Every level receives the communication with an active attitude. The communication which is so picked up is analysed, amplified, and further planned at a higher level of detail.

This entails that broad policy decisions given in general terms, originating at Level V, are carefully studied, amplified and detailed plans worked out by Level IV staff. Communication from Level IV is actively and meaningfully amplified by Level III and so on.

The "Schematic model" has a number of features significant for efficient and adequate management and execution. But the one detailed feature which has been indicated and which is associated with the "unit process" 1.0 and which is symbolized by the sub-cyclic modifications is specially important. The five unit operations of U.P. 1.0 are particularly noteworthy.

In addition to these the schematic model gives an overview of the main pattern of communications, formal and informal, which must occur within the entire system if a project is to proceed with adequacy.

It will be observed that the analysis presented here is essentially "process-oriented". It concerns itself with the significant processes and the operations associated with a project. The analysis, therefore, deliberately seeks to reveal the generalised pattern of action which underlie a mass of administrative operations which at first sight appears diverse and different. The analysis postulates that diverse activities such as the design and implementation of curriculum programmes, the design and implementation of in-school feeding programmes,the design and implementation of the building facilities in school, and the design and operation of a work experience programme etc. etc. are all essentially similar, in terms of the processes and operations involved in their execution. The actual raw material which feeds the processes and operations in a given instance may be different from that in another instance.

In an analysis where an abstraction of the above type is made, many features that are relevant are inevitably left out. To this extent the analysis and the schematic model are limited. But it is postulated that for growth and development in terms of adequacy, from a professional management stand-point the analysis presented may be specially valid. It may, in fact, be more useful than looking at the specific details that may obtain in a given situation, though attention to the latter is necessary to execution.

In the context of the above comment, the analysis and schematic model should be used having regard to its nature and limitations.

In any given situation it would be useful to seek to apply the analysis and the schematic model, first by interpreting it and translating it and translating it into the particular idiom of the activity that is specifically under consideration. In this process, it may, in fact, be possible to formulate the analysis and the model in a way that may be particularly appropriate for the task in hand. In some cases it will need to be adapted to suit the particular situation.

It is important to recognise that the analysis and the model do not seek to provide ready-made solutions to given problems, it indicates a pattern of thought. It provides cues to the recognition of problems and the analysis of problems. Used appropriately, it may be very helpful in recognising alternative solutions and criteria of choice as well.

It is a "mental scaffolding". The execution of the project itself is the principal task. Intelligent professionals use "scaffolding" to facilitate the building of the main structure. The scaffolding is then dismantled and re-erected at another project site. Large scale professional operators use discriminately designed scaffolding; and they use specific designs for specific purposes. The versatality with which scaffolding is used reflects the experience and ability of the user. The very able operator uses the minimum of it, yet has ready access to all parts of the structure; and also, he uses "multipurpose" type that has great flexibility. It may be appropriate to note that well designed scaffolding has a rugged, cold elegance of its own.

The organisational system which has been considered in this study is a particularly complex one. A multitude of various activities occur within it and these occur at a multitude of levels in a widefield. It is, in fact, an understatement to describe it as a complex system. To this extent its analysis must necessarily present peculiar difficulties, especially when an attempt is made to take note of it and study it as a whole.

No apology, therefore, needs to be made for the rather involved nature of the analysis and the "Schematic model". Both reflect validly the intricate nature of the system which they seek to interpret.

The purpose of a model is to describe, explain, or predict the performance of a system. By definition, an analytical model seeks to classify the various structural and functional units within the system. On the basis of such classification it seeks to abstract and generalize. In this process some aspects are invariably left out. This must be consciously recognised. A useful "model" should explain and predict not only the behaviours of the system as a whole, but of significant components within it. The model should also, if it is really powerful, be able to indicate the response of the system to change of one or more of its components and the effect on the system in general of "internal" and "external" disturbances.

The model presented in this address may not meet all these criteria. It will need to be tested for workability. But it is important to recognise that a model need not be applicable in all contexts. The real issue that a user of an "analytical model" should seek to resolve is the degree of usefulness of the model. He should seek to understand the specific contexts in which the analysis or the model can serve.

In the analysis and in the schematic model the following significant working assumptions and assertions are made:—

1. The level of operation differs in kind and range from the policy making level to the operational level in the class-room.
2. Although differences exist, it is postulated that the basic functional operations at the varying levels have close correspondence.
3. It is, in fact, postulated that in the ideal situation the sequence of basic processes and operations is identically the same, in kind, regardless of the level.
4. The analytical framework presented is described in an idealised logical manner. But it is not postulated that in actual reality, these operations always occur in this idealised sequence.
5. A very significant factor of this analytical framework and schematic model is the unending cyclic operations leading to continuous adaptation and growth.

6. While it is postulated that there is a single main channel of communication and of authority, the schematic model indicates vividly the complex pattern of semi-formal and informal articulation and communication.
7. The principal unit process and unit operations are identified and described.
8. The analysis is necessarily complex. The description in words of a complicated organised entity such as the educational system is in itself a difficult task.
9. The schematic model has been drawn in two dimensions but little reflection will indicate that it is, in fact, one that may be better drawn in three dimensions.

3.0—CONCEPTUAL ANALYSIS RELATING TO MAJOR EDUCATIONAL OBJECTIVES

A major problem in the field of educational development relates to the design of curricula. Considerations such as in the sequel assist in placing it in perspective. The process of change already referred to has several dimensions. From one standpoint there are the demographic, social and economic pressures that directly bear on the work of the school. Not only are the numbers of pupils increasing rapidly, but the variety of purposes for which they need to be educated effectively is also becoming highly differentiated, specialized, and at the same time is rapidly changing. Furthermore, the costs of education are rising rapidly. Above all a recourse which cannot be extended, namely—TIME—places severe restrictions on the entire activity that takes place within the school.

Knowledge is increasing rapidly, technologies and techniques are changing, and simultaneously new techniques and technologies are emerging. New insights are being gained in relation to how people learn and adapt their learnings in life.

Perhaps a most significant factor of the present is that educators are functioning in reality for the first time in a context—which had earlier been only of academic interest. The assumption that one could consider an individual's life path as constituting two major phases—a phase wherein he learns and educates and trains himself, and a phase of activity wherein he utilizes his learning, skills, etc.—is for the first time in the history of mankind operationally invalid. The theoretical idea of continuous learning is now an inescapable fact. The need to go on continuously learning and retraining, re-educating oneself has become not an academic theoretical principle but a relatively hard practical fact in today's world. Trained educated people are becoming obsolete quite rapidly in the context of a rapidly changing technology and an associated rapidly changing pattern of societal living. The whole education system has to therefore take cognition of the need to re-organize itself to cope with this changed outlook in relation to human living. It becomes therefore, much more important that people should learn to learn effectively rather than merely acquire selected facts, specific skills or values. With this pattern of change as a background, the school, as the main agency charged with providing environment for learning, has had focussed on it the concern of the community.

The suitability for today of the entire curriculum of the school, and certainly many major parts of it, has been seriously questioned. Many questions such as following have been actively raised:

1. Is the school teaching the appropriate content to its pupils?
2. Is the manner of teaching it appropriate in the context of the broad patterns of change?
3. Is the pace at which it is taught a valid one?
4. In the context of the high adaptability and transfer of learning which is demanded, is the curriculum of the school appropriately organized and sequenced?

All these questions and many others are being raised. In fact, hardly any objective of the school curriculum has failed to be questioned and subjected to critical review in the recent past.

The above problem when it is considered more particularly and in a limited way may be looked at thus. It is asserted often that pupils should be educated so that the pupils *not only can remember but also know* and *understand.* It is asserted that the pupils should *not only be able to recall* but should also be able *to value and appreciate.* It is suggested that not only should pupils be able to recall, comprehend analyse, but that they should be able *to effectively do things.* What is the nature of the commission given to the school, and what do these requests imply for the programme of work in the school? With severely limited resources of men and materials and even more severely limited resources of TIME how does the school organize itself to do the things which it is expected to do?

More specifically one can ask this question in relation to the various areas within the curriculum in these terms: How does one design the content and methodology within the curriculum area 'X'? Furthermore, other questions are raised. Assuming that a design of curriculum area 'X' can be achieved, how does one evaluate and assess whether the goals set out have been reached? In other words, one raises the questions: Are the current tests and examinations valid? What are the specifications of these tests and examinations? What are their limitations? How may they be developed, adapted, improved, and extended?

These and a host of other questions are presented to the educational designer and administrators.

As an active positive response, educational designers have sought to understand the following things:

What is it *to know and understand*?

What is it *to appreciate and feel*?

What are the implications of the term "*to do*"?

All of these questions have been raised earnestly by educational curriculum designers in the context of the design of learning and the re-construction of assessment procedures.

In formal terms the above comments may be stated to imply that educational designers have considered the objectives of education in the cognitive dimension, affective dimension and the psycho-motor dimension. Each of these areas of human activity have come in for critical study.

In so far as the concern that has been generated is specifically in relation to *the practices* and *procedures* that obtain within the schools, these questions, which have been considered from time immemorial, are *now* being considered not merely from the philosophical and other stand points, but very difinitively *in operational terms.* In describing them in relation to the learner, efforts have been made to describe educational objectives in observable behaviourable terms.

A classic study (Bloom, 1956) in this context is:

A Taxonomy of Educational Objectives.
A Classification of Educational Goals—Handbook I.
Cognitive Domain, Bengamin S. Bloom, *et al.*, 1956.

A related study (Krathwohl, 1964) is:

A Taxonomy of Educational Objectives.
A Classification of Educational Goals—Handbook II.
Affective Domain, Krathwohl D.R., *et al.*, 1964.

The impact of these studies, more particularly the first one, in the context of educational curriculum design has been specially noteworthy. These studies have provided not only theoretical conceptual analysis of a significant area in educational design in operational behavioural terms but also provided effective communication among educational designers. Effective communication has been achieved primarily because the analysis seeks to limit itself to the operational aspects of the situation. It has led to the acceptance for a number of significant conventions among educational designers, and has undoubtedly led to the integrated accumulation of experience in educational design.

An outline summary of the Taxonomic Analysis in the above Handbook I and II is given below:—

1. The cognitive continnum begins with the student's Recall and Recognition of Knowledge (1.0)	1. The affective continuum begins with the student's merely Receiving (1.0) stimuli and passively attending to it. It extends through his more actively attending to it.
2. it extends through his comprehension (2.0) of the knowledge,	2. his Responding (2.0) to stimuli on request, willingly responding to these stimuli, and taking satisfaction in this responding,
3. his skill in Application (3.0) of the knowledge that he comprehends,	3. his Valuing (3.0) the phenomenon or activity so that he voluntarily responds and seeks out ways to respond,
4. his skill in Analysis (4.0) of situations involving this knowledge, his skill in Synthesis (5.0) of this knowledge into new organisations,	4. his Conceptualization (4.1) of each value responded to,
5. his skill in Evaluation (6.0) in that area of knowledge to judge the value of material and methods for given purposes.	5. his Organization (4.2) of these values into systems and finally organizing the value complex into a single whole, a Characterization (5.0) of the individual.

In the series of Taxonomic exercises referred to "X" above, the Handbook III, relating to the "psycho-motor dimension", has not yet appeared. A relevant study has been worked out by the Ceylon Curriculum Study Group (Alles, 1967). An ordering principle for the psychomotor aspects of behaviour has been reported by the author at these sessions of the Ceylon Association for the Advancement of Science. The paper is titled:

"A Preliminary Report on an Ordering Principle For and a Contingent Analysis of Psycho-motor Aspects of Behaviour".

At attempt has been made in this paper to complete the conceptual analyses available for curriculum design by providing the basic thinking essential for the psycho-motor aspects of behaviour.

The paper recognizes three basic levels of execution in the psychomotor area namely the following:

1.0 : Initiatory Level of Execution

2.0 : Pre-Routine Level of Examination.
  2.10 Pre-Routine Non-adaptive Sub-Level.
  2.20 Pre-Routine Adaptive Sub-Level.

3.0 : Routinized Level of Execution
  3.10 Routinized Non-adaptive Sub-Level.
  3.20 Routinized Adaptive Sub-Level.

The main purpose of the paper is the reporting of the number and the associated ordered system of levels of psycho-motor execution. It is asserted that this number and the set of levels may be specially useful as a theoretical tool for the evaluation of learning of psycho-motor behaviour sequences.

In short, it provides an interpretation—a graded sequence in operational terms, of the verb, *to do.*

Although these studies cited above have provided a significant advance in a specific field of educational curriculum design and evaluation practices, nevertheless, critical analysis of these conceptual studies indicates that further development and refining is readily achieved. No attempt will be made in this address itself to argue the entire sequences of limitations and the possible patterns of development of the above studies.

An initial working paper outlining a positive line of development has been published by the Ceylon Curriculum Development Group of the Ministry of Education and the publication (Alles, 1967) is titled:

"Theoretical Constructs in Curriculum Development, and Evaluation, Ministry of Education, Ceylon, Alles, Jinapala *et al.*, 1967".

The conceptual studies referred to above are definitive attempts by educational designers to explicitly analyse various educational objectives so that a continuing dialogue among professional designers in relation to education objectives can be achieved. The purpose of the theoretical constructs referred to above is the evaluation of communication techniques among educational designers so that accumulative, progressive and systematized growth in educational objectives and in the specification of content and in the design of evaluation instruments can be achieved.

It is clear that the area in which this mode of conceptual analysis and classificatory techniques are used, one which is subtle and one involving a variety of value judgements. The attempt to explain the objectives and express them in operational behavioural terms, may be one which unlikely to succeed entirely adequately. The nature of the area of human activity that has come in for consideration is undoubtedly complex in the extreme. Nevertheless, it is suggested that a significant step forward has been taken in a direction that may lead to the solution of some of the problem of education design.

Having regard to the nature of the area under consideration it may be that in the future when more adequate and consistent and comprehensive designs will be available, such conceptual analyses as achieved now may appear somewhat premature. Nevertheless they have elements associated with them which are fundamentally valid.

4.0: CONCLUDING COMMENT

At a first glance and on an initial study the analyses, and the models, they may appear unnecessarily complex and perhaps confusing. They may also perhaps appear sterile and biased towards the theoretical. Both these reactions may be partly valid. Many high level executive staff are steeped in a multitude of urgent pressing day-to-day organisational and administrative problems. This diversion of attention to theory in relation to administration, and organisation, and the pre-occupation in this address on conceptional analysis, may appear quite unnecessary and may even appear, perhaps, a useless exercise.

It is important to note that this model and mode of analysis are unlikely to have meaning, and may perhaps continue to appear sterile unless actually applied actively in day to day work.

Management of enterprises in general has developed significantly in recent decades. From a particular standpoint, a significant trend can be recognized. Progressively specific descriptions—specially useful and necessary in day-to-day execution of tasks—have been *supplemented* by generalized descriptions. In turn these have developed in diverse ways such as the following:

Static descriptions have evolved to dynamic ones. "Product" orientations have evolved to "Process" oriented patterns.

Concrete ones with limited scope have given place to abstract ones with wider applicability.

Qualitative descriptions have been superceded by ones with greater potential for mathematical treatment and "symbol use" etc.

In general, the following is in the main true:

"What has now become decisive for society is the new centrality of *theoretical* knowledge, the primacy of theory over empiricism, and the codification of knowledge into abstract systems of symbols, that can be translated into many different and varied circumstances" (Bell, 1967).

Commonality in terms of conceptual structural aspects is likely to become increasingly critical as the major determinants of organisation. It is likely that specific "task-oriented" and specific "mission-oriented" modes of thought will become subsidiary. They will *certainly* need to be supplemented. The full exploitation of modern technology may demand quantifiable mathematical modes of thought and analysis. An overall "systems" approach will become essential. The validity of such approaches is no longer debated. The important thing is to be aware of both the limitations and power of specific "models" for action. Deliberate rejection or acceptance is needed, and not the failure to use on account of ignorance or lethargy.

Reality is complex. It is not always readily comprehended. Even if comprehended, analysis, synthesis, and evolution may elude us. These may be possible, and yet our ability to evolve suitable representations for particular or general purposes may only succeed partially. Or further, the mathematical and other tools available may be limited. Notwithstanding, in the management of complex systems with a multiplicity of interactions such as here considered, all techniques should be exploited to the limit. The ability to handle conceptual structural "models" enables whole classes of problems to be resolved. What is needed is the ability of the decision maker to see the relevance of a particular model in a given situation; and the clear recognition of the limitations that bear on the use of modes of thinking such as considered here.

In the design of these analyses and schematic models the fact that the education system is serving a developing country with parts of the society in various stages of socio-economic development is not lost sight of. In this context, the following quotation taken from one of the studies (Hanson, Brembeck and Cole, 1966) may be one which is very appropriate to reflect on:

> "If this concern for theory appears remote from that small boy driving an ox around a Persian water wheel on the Punjab plain, who was introduced at the opening of this volume, it is only because appearances are misleading. Our concern with his welfare is not the less because our concern with the theory is the more. Any educational theory worthy of respect is concerned centrally with him, and with countless numbers like him. And if we call attention to him, again, at the conclusion of this volume, it is to restate our underlying conviction that the ultimate vindication of any educational theory, of any education itself, lies in the richness and meaning it gives to the lives of those who receive it and, in our time in much of the world, to the lives of those less fortunate ones who must still profit indirectly from their brothers' experience. It is well for all engaged in education for development to remind themselves periodically that this is their vindication".

The conceptual schemes here presented in outline have potential for use in such contexts. In them may lie centres of growth from which may evolve comprehensive conceptual frameworks that may be of service to educational management in the "turbulent" years ahead.

References

Alles, J. (1958). Science Laboratory Equipment for Secondary Schools—An Analysis. Proceedings of the XIVth Annual Sessions of the Ceylon Association for the Advancement of Science, December, 1958—Colombo.

Alles, J. (1961). The Science Teaching Laboratory. An Analysis—Unpublished Thesis, Cornell University, New York.

Alles, J. (1963). Science Laboratory Equipment for Secondary Schools—Teaching, March 1963, Vol. XXV, No. 3—O.U.P., Bombay.

Alles, J. and Zakrzewashi, G. (1963). Proceedings of the Conference on Research for Educational Planning in Asia—Tokyo, 1963, UNESCO, Paris.

Alles, J. (1967). Theoretical Constructs in Curriculum Development and Evaluation, Ministry of Education, Ceylon.

Alles, J., De Silva, S. V., Kulatunga, F. W. W. (1966). Costs and Financing of Education in Ceylon—1952-1964—UNESCO, Paris.

Alles, J. (1967). Notes on Structural and Functional Aspects of and An Educational System relevant to Educational Administration—Ministry of Education, Ceylon, 1967.

Alles, J. (1967). An attempt at Re-structing Some Conceptual Frameworks used in Curriculum Development and Evaluation—Proceedings of the Ceylon Association for the Advancement of Sciences—Section F—1967.

Alles, J. (1967). A preliminary Report on an Ordering Principle For and a Contingent Analysis of Psycho-Motor Aspects of Behaviour—Proceedings of the Ceylon Association for the Advancement of Sciences—Section F, 1967.

Archambault, Reginald D. (1965). Philosophical Analysis and Education, Routledge and Kegan Paul, London.

Bell, D. (1967). Note on the Post-Industrial Society "The Public Interest," Vol. 6, p. 24-35, Wintor, 1967.

Bloom, B. S. Ed. (1956). A Taxonomy of Educational Objectives, A Classification of Educational Goals—Handbook I—Cognitive Domain, Longman Green & Co., U.S.A.

Bereday, G. Z. F., Lauwerys, J. A., Blaug, M., (1967). The World Year Book of Education 1967 Educational Planning, Evans Brothers, Ltd., London.

Coombs, P. (1967). The World Educational Crisis—A System Analysis—IIEP—Paris—August, 1967.

Dewey, J. (1929). Source of a Science of Education, Liveright Publishing Corporation, New York.

Department of Education and Science (1966). Trends in Education, January 1966, Her Majesties Stationery Office, London.

Hanson, J. W. and Brembeack, Cole S. (1966). Education and the Development of Nations Holt, Reinhart and Winston, London.

Krathwohl, D. R. Ed. (1964). A Taxonomy of Educational Objectives, A Classification of Educational Goals, Handbook II—Affective Domain, David Makey Co. Inc., U.S.A.

Larrabee, H. A. (1945). Reliable Knowledge, Houghton Mifflin Company, Boston.

Litchfield, E. H. (1956). Notes on a General Theory of Administration, Administrative Science Quarterly, Volume I, No. 1 (June 1956) Chicago.

McFarland, D. E. (1966). Current Issues and Emerging Concepts in Management, Volume Two, Houghton Mifflin Company, Boston, New York.

Ross, D. H. E. (1958). Administration for Adaptability, Metropolitan School Study Council, New York, 1958.

Schlender, W. E., Scott, W. G., Filley, A. C. (1965). Management in Perspective, Houghton Mifflin Company, Boston, New York.

The Schools Council (1967). Educational Implications of Social and Economic Change H.M.S.O., 1967.

UNESCO—Paris (1965). World Survey of Education, Vol. II—Secondary Education, 1961.

UNESCO—Paris (1965). Perspectives of Educational Developments—1961—1980—A Draft Asian Model.

ADDRESS TO SECTION A

AN OUTLINE OF RESEARCH HISTORY OF THE TSUTSUGAMUSHI DISEASE IN NIIGATA PREFECTURE OF JAPAN

by

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I. DOCUMENTS IN CLASSICAL ERA

The word "Y" appeared in one of the documents of Latern Han era. 25 to 225 A.D. and was explained as "stricken with grief" or "an insect sticking to the human beings". In 586 to 609 A.D. this character took a representative meaning of the shape and the name of a noxious insect living at the waterside. By these statements it was believed that there was the noxious insect in old China similar to those in Japan.

The oldest document about the Tsutsugamushi disease described in Japan, especially in Niigata Prefecture was traced back in 1754. In 1836 MOTOKATA TAKI described succinctly as such, "there is a disease in the area of Niigata in Echigo. If one works moving in the waterside near the sea, the mites will attach themselves to his skin and bore into it. This mite is too small, not as easily discernible. If one gets a bite, he becomes febrile as if he were stricken with severe disease. People call it "tsutsuga". It may cause bites by the "Sand-louse or so". Since then, for well over 200 years, this disease had been dreadful as an evil to the local people, they tried to get rid of this disease simply by praying to God and Buddha. This ceremony had disappeared about 50 years ago and not present nowadays.

Classical areas of the Tsutsugamushi disease in Japan are limited to the basins of the Shinano river, its branch the Uono river and of the Agano river in Niigata Prefecture, the Mogami river in Yamagata Prefecture and the Omono river in Akita Prefecture. We can find many old documents mentioning about this disease in each prefecture, though there were some discrepancies of time which were written.

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II. DEVELOPMENT OF ECOLOGICAL AND SCIENTIFIC RESEARCH

The first ecological survey of the Tsutsugamushi disease in Niigata Prefecture was carried out in 1876 by the section of public hygiene in prefectural office. They made a statistical survey of the patients and organised a local temple "Gan Keiji" at Kurozu village near the Shinano river to a hospital taking care of the patients. Interesting enough to us, two autopsies were performed in that year. This tentative hospital was visited by many investigators, including several foreign scholars. Among them, Dr. E. Baelz was worth to mention. He came to treat the patients and made an ecological investigation of "Yudokuchi" in 1877 and 1878. In 1878 first scientific report written in Japanese was published by YANO and in the next year first paper written in German was made by BAELZ and KAWAKAMI in Virchow's Archiv Bd. 78, titled "Das japanische Fluss-oder Ueberschwemmungsfieber, eine Infektionskrankheit". In 1904, Committee of the Tsutsugamushi disease in local medical group, Hokuetsu Medical Society reported systematic clinical symptoms of the disease. The governor of Niigata Prefecture by the decree declared in 1905 had physicians to report the patients when they saw. At that time following names were the doctors who investigated on the Tsutsugamushi disease. Drs. HAYASHI, UKAI, KITAJIMA, ASAKAWA, MIYAJIMA, M. OGATA, ISHIHARA, KAWAMURA and N. OGATA. And also were Dr. TANAKA in Akita, Dr. NAGAYO and others in Yamagata Prefecture.

III. TROMBUCULID MITES IN CLASSICAL NOXIOUS AREAS "YUDOKUCHI"

Since Dr. PHILIP and others discovered a new type of the Tsutsugamushi disease near Mt Fuji in 1947, which were indifferent from the flood of the rivers, the districts of Tsutsugamushi infected areas in the basins of the rivers in northern Honshu have been called the "classical noxious areas" or "yudokuchi" in Japan. Until 1902 it was believed by local people that there were two kinds of the mites which bore the human skin. One was noxious "tsutsugamushi", "akamushi" and "shimamushi", and another was not noxious "chigayamushi" "ogimushi" or "yanagimushi". Drs. MIYAJIMA, UKAI, HAYASHI and others discussed the differences of these mites since 1902, and finally two kinds of the mites were concluded as same in species.

In 1910 Dr. MIYAJIMA sent the specimen of the trombiculid mite to Dr. BRUMPT who named it "*Trombicula akamushi*" later. However, in 1916 Dr. TANAKA in Akita Prefecture made an observation that there were a different mite other than *Trombicula akamushi* and many investigators found new mites one by one according to his clue. During 1916 to 1920 six kinds of the trombiculid mites had been established by Drs. HAYASHI, OKUMURA, NAGAYO, KAWAMURA, and others. The late Professor KAWAMURA classified them in A, B, C, D, E′ and E″. They corresponded to *Trombicula akamushi, T. scutellaris, T. palparis, T. pallida, T. japonica and T. tamiyai.*

IV. DISCOVERY OF CAUSATIVE AGENT, RICKETTSIA

As a causative agent Drs. BAELZ and KAWAKAMI proposed miasma of the flood. Dr. KITASATO in 1893 assumed a plasmodium-like microorganism as an agent. Drs. KITAJIMA, MIYAJIMA reported a successive transfer of the disease to Japanese monkeys. As tabulated, the proposals of bacteria, protozoa, toxin and others as a possible agent had been listed and entered in next new period. Keen enough Drs. HAYASHI, NAGAYO, KAWAMURA, N. OGATA and others, then entered in investigation, had noticed that the agent might be an unusual one hitherto undescribed. The research in the aetiology of the Tsutsugamushi disease had accelerated in concert with the discovery of causative agent of typhus which was epidemic in many countries in the world in about 1910 and was finally named as *Rickettsia prowazeki.* In 1924 Dr. NAGAYO and others found a microorganism in the blood or the tissues of infected monkeys and said that it had a similarity with the characteristics of rickettsia. In 1927 Drs. ISHIHARA and N. OGATA made a successive inoculation of the patient's blood to the rabbit tests, found an intracytoplasmic microorganism in the tissue in the next year. Although they said it looked like rickettsia, they did not name it. April in 1930 Dr. NAGAYO and others observed numerous microorganisms in the cells of Descemet's membrane in the cornea of the rabbit which were inoculated with patient's blood in the anterior chamber. They gave a name of *Rickettsia orientalis.* One month later in the same year, Dr. N. OGATA coined as *Rickettsia tsutsugamushi* to the microorganism he found in 1928. Dr. Hayashi changed his *Theileria tsutsugamushi* to *Rickettsia tsutsugamushi* in 1931. Priority and naming are still a matter of controversy and not settled at this moment.

Process in Discovery of Possible Agents of Tsutsugamushi disease

Reporters	*Year*	*Agents*	*Ways of Discovery*	*Classification*
Baelz and Kawakami	1879	Miasma	Hypothesis	Toxin
Kitasato, S	1893	*Plasmodium*	Patients blood	Protozoa
Tanaka, K.	1899	Proteus		Bacteria
Asagawa and Miyajima	1905			
Hayashi, N.	1909	*Theileria tsutsugamushi*		Protozoa
Nagayo et al.	1915	Protozoa-like bodies		Protozoa
Hayashi, N.	1917	Piroplasma	Autopsy material	Protozoa
Miyajima, M.	1918	*Chlamydomyces akamushi*	T. akamushi	Protozoa
Ogata, M.	1917	Fungus	Blood culture	Bacteria
Nagayo et al.	1919		Lymph nodes	
Ishihara and Ogata	1919		Lymph nodes	Bacteria ?
Hayashi, N.	1920	*Theileria tsutsugamushi*	Lmyph nodes and blood	Protozoa
Sellards, A. W.	1923	*Rickettsia nippinica*	Blood culture from infected monkey	Bacteria
Nagayo et al.	1924	*Rickettsia ?*	Tissue from infected monkey	New organism
Ishihara and Ogata	1927	None	Inoculation to rabbit's tests	Intraoellular micro-organism
Ishihara and Ogata	1928	*Rickettsia ?*	Inoculation to rabbit's tests	Rickettsia ?
Nagayo et al.	1930	*Rickettsia orientalis*	Inoculation to rabbit's anterior chamber (of eye)	Rickettsia
Ogata, N.	1930	*Rickettsia tsutsugamushi*	Successive inocculation to rabbit's tests	Rickettsia
Kawamura, R et al.	1931	*Rickettsia akamushi*	*T. akamushi*	Rickettsia ?
Hayashi, N.	1931	*Rickettsia tsutsugamushi*	Changed from Theileria	
Ogata, N.	1935	*Rickettsia kedani*	Changed from R. Tsutsugamushi	
Miyairi, K.	1935	Haemogregarine	Blood of rodents	
Kawamura, R.		*Rickettsia tsutsugamushi-orientalis*	Proposition	Protozoa

V. DISTRIBUTION AND SEASONAL VARIATION OF THE TROMBICULID MITES IN NIIGATA PREFECTURE

The investigation about the distribution of the trombiculid mites in Niigata Prefecture was carried out by Drs. MIYAJIMA, HAYASHI, KAWAMURA and others. They placed a point of the surveys in the districts where the patients reported and nearby basins, and did not pay much attention to the areas other than classical noxious districts. Though since Dr. PHILIP and others discovered a new infected area which was indifferent with the river, reinvestigation for searching the mites was carried out in several areas, resulting in a discovery of undescribed kinds of the trombiculid mites. We made surveys over the rivers and their upstream mountain districts in this prefecture in total hundred spots for 2 years since 1950, collected 15 kinds of mites. Later reinvestigation brought up three more kinds of mites and total 18 kinds were registered. Simultaneously the search for the agent as well as the identification of the mites were made. The field mice collected were of total 13 species.

In 1920 the late Professor KAWAMURA and others investigated on the Tsutsugamushi disease in the village, Kosugi in the basin of the Agano river which was most severely infected with the disease. In 1924 they classified the mites in total 6 types, and made clear their seasonal occurrence. The result of a follow-up survey made by Dr. OBATA in 1951 showed same in accordance with that of Dr. KAWAMURA. *Trombicula akamushi* begins to appear in early May, reaches to maximal number in July and August and disappears in late November. *Trombicula pallida* is seen frequently in autumn, although found during February to November. Trombicula palparis is between February to June and September to December. *Trombicula japonica* between September to December. *Trombicula tamiyai* appears during January to May and October to December. In Dr. Kawamura's investigation, *Trombicula intermedia* was not found, on the contrary *Trombicula scutellaris* (KAWAMURA B) was described that it appeared frequently during September to November, we were not able to find it in our surveys. What was characteristic in the survey on the lower Shinano river was that *Trombicula ntermedia* appeared explosively in August and September.

VI. ECOLOGY OF THE TSUTSUGAMUSHI DISEASE

1. Number of patients and mortality

This table indicates the incidence, number of death rate and the mortality since 1903. Namely total patients 4968 were between 1903 to 1955, number

of deaths 1441 till 1951 and mortality was 31.18%. Annual incidence since 1933 was below 100 and remarkable decrease was obtained. It was believed that the habitats of the vectors became cleared by the scientific discovery of disinfection, the extermination of the field mice, clothing for protection (Kawamura's method) and inadequate living conditions for the mites and the field mice by several riparian works. Dramatic effect of the antibiotics which was introduced in 1948 brought the incidence of the patients down annually to only 1 death in 1951. Mortality rate has become nought since 1951.

Number of Patients with Tsutsugamushi Disease and the Mortality Rate in Niigata Prefecture

Yr.	*No.*	*D.*	*Rate* %	*Yr.*	*No.*	*D.*	*Rate* %	*Yr.*	*No.*	*D.*	*Rate* %
1903	219	56	25.6	1924	32	7	21.8	1945	8	3	37.5
1904	278	89	32.0	1925	42	7	11.6	1946	34	6	17.7
1905	125	29	32.0	1926	16	6	37.0	1947	40	9	22.5
1906	195	54	27.7	1927	45	12	28.6	1948	36	12	33.3
1907	254	72	28.5	1928	10	0	0	1949	30	3	10.0
1908	262	79	30.2	1929	20	5	25.0	1950	97	4	4.38
1909	192	52	27.1	1930	37	9	24.4	1951	59	1	1.69
1910	175	48	27.4	1931	41	16	39.0	1952	65	0	0
1911	47	12	25.5	1932	51	20	39.2	1953	55	0	0
1912	71	26	36.6	1933	130	43	33.1	1954	48	0	0
1913	94	32	34.0	1934	79	23	29.1	1955	30	0	0
1914	175	57	32.6	1935	43	15	34.8	1956	20	0	0
1915	224	78	34.8	1936	31	11	35.5	1957	21	0	0
1916	209	64	30.6	1937	32	10	31.2	1958	8	0	0
1917	186	94	50.5	1938	68	27	39.7	1959	13	0	0
1918	216	86	41.0	1939	50	21	42.0	1960	19	0	0
1919	62	25	40.3	1940	63	26	41.2	1961	24	0	0
1920	119	38	31.9	1941	37	13	35.1	1962	27	0	0
1921	102	32	31.1	1942	69	27	39.1	1963	11	0	0
1922	81	29	35.8	1943	43	21	48.8	1964	3	0	0
1923	54	17	31.5	1944	37	15	40.5	1965	3	0	0

2. Geographical features and distribution of classical noxious areas "yudokuchi"

The habitats of the common vector *Trombicula akamushi* were limited in the downstream of the Agano river, in the downstream from Nagaoka of the Shinano river and in the midstream of its branch the Uono river. In areas of the upstream in these rivers, the vectors are rarely found. The Shinano river has divided its stream at Okozu in 1931 and new incidence of the Tsutsugamushi disease reported from this basin. In the interior of the bank including the holms which frequently flooded over in summer, the vectors live among grasses and in the farms and they did not live in outside of the bank. The interior of the bank is fertile and renting cost is cheap, so is suitable for moving, promising for rather large amount of crops than the areas outside of the bank.

The total number of the village in Niigata Prefecture where the Tsutsugamushi disease occurred counted to 141, among them 71 were not ever changed from the yudokuchi, 30 were once yudokuchi reached to 40. It can be said that the yudokuchi move from place to place in small scale. The habitats of the vectors in other countries are in the woods, the rubber plantation or the grassy plain which are indifferent with the floods. Why are these classical noxious areas limited to the basins of the river frequently overflooded in summer season in Japan? Our extensive surveys of the rivers in Niigata Prefecture did not give a clear answer to this question.

VII. BREEDINGS OF THE TROMBICULID MITES IN LABORATORY

Since the clarification was made that the larvae parasitically infected to the field mice in yudokuchi, Drs. MIYAJIMA, NAGAYO, and KAWAMURA made clear almost simultaneously of the life cycle of the trombiculid mites. Although breedings, living conditions especially their eating habits have been matters of energetic research thereafter and they are still not completely solved. Breeding in various containers with eggs of several other insects especially those of mosquito as a food to the mites was successful in laboratories of several investigators.

We used colorless plastic dishes by SASA containing mixed powder of plaster, activated charcol and water as described by WHARTON AND CARVER in 1944 as a medium, and in there placed eggs of dragon flies, Sympetrum frequens. The temperature of the rearing was at room temperature in summer, and was in incubator at 20°C in seasons. Eggs

of dragon flies were immersed in 0.5% sodium chloride and kept at—3°C were adjustable as a food for 6 months. In 1940 and 1951 by using the flowerpot method, the late Prof. KAWAMURA took 300 days for one cycle of the mites. The larvae of *Trombicula akamushi* reared in our laboratory, we made the mites attached to the mice and fed them with eggs of dragon flies, the larvae turned to adult in 26 days, producing eggs after 11 to 12 days and new larvae hatched out from these eggs in average 13 days.

Namely total 52 to 53 days were required for once cycle of the life history including 2 days of attachment to the mice.

Multiplication of the trombiculid mites was by gamogenesis not by agamogenesis. For example 12 female mites did not produce eggs for 21 to 132 days if separated from the male. The adults of 23 to 30 days old were co-habited, and 2 out of 12 mites began producing eggs 11 days later.

Number of eggs one female produces varied from each other, 314 to 414 in multiparious group, 29 to 2 eggs a day.

The larva which did not stick to the mice jumped and turned laterally at room temperature of over 22°C.

The rearing of *Trombicula pallida* and *Trombicula intermedia* was easily obtained by feeding the eggs of dragon flies.

Speaking on development of the larva attaches experimentally to human beings, the hatched larvae of *Trombicula akamushi* were made attach themselves to two human volunteers, seven out of collected 23 mites were reared again. Six became adult and the female mites began producing eggs after 31 days in a total of 60 eggs. Sixty percent of these eggs hatched out as new larvae of the third generation. As a conclusion the larvae stick to the human beings, develop and multiply under an equate rearing care.

LECTURE TO SECTION C

NETWORK ANALYSER AND DIGITAL COMPUTER FOR THE STUDY OF POWER SYSTEM PROBLEMS

by

C. S. GHOSH

1. INTRODUCTION

During the last two to three decades, Electrical Power Systems have grown enormously and with that the problems of System Design and Operation. In analysing interconnected, multi-machine systems, for both steady-state and transient stability, long-hand methods have become almost useless. This led to the development of various aids for the solution of this problem.

The first one to be developed was the D.C. Network Analyser and then came the A.C. Network Analyser, both for the study of steady state operation. For transient studies, Differential Analysers (Mechanical and Electronic) were employed. Due to the limited accuracy of these and the difficulty in representing complete interconnected systems, micro-machine models were later employed to study the effects.

With the advent of the Digital Computer, the conventional Network Analyser and even the Analog Computer (Electronic Differential Analyser) have become obsolete for the purpose of studying Power Systems.

The modern Network Analysers are based on the equivalent single phase per unit representation of the system. Complex computations are realised using symmetrical component theory.

All modern network analysers operate on the same principle but the supply frequency may vary from 50 C/S—10 KC/S. Different units and metering arrangements are employed in different designs, some being equipped with servo operated units to cater for automatic voltage control. Usually the control panel consists of master instruments, such as Ammeter, Volmeter, Wattmeter and Varmeter, and circuit selector units, capable of connecting the meters to any desired circuit. Miniature Network analysers are available for studies on simple systems.

Confusion sometimes occurs between the functions of a Transient Analyser and a Steady State Power System Analyser. The power system analyser deals essentially with steady state analysis whereas the Transient Analyser is used mainly for short time natural frequency oscillations excited by arbitrary forcing functions.

2. USE OF NETWORK ANALYSERS

The different problems that can be solved on a modern network analyser are:—

1. Load flow studies
2. Short circuit studies
3. Stability studies
   - *a.* Steady state
   - *b.* Transient state
4. Economic operations
5. Load frequency control applications
6. Other miscellaneous studies including network reduction.

2.1 LOAD FLOW STUDIES

This involves the determination of the voltage, current, power factor or reactive power at various points in a network under existing or anticipated conditions of normal operation. Such studies are essential from the point of view of planning for future development. Most often the network analysers are employed for the purpose of load flow studies.

In doing a load flow study, it is necessary to specify the operating conditions for the network. Usually the net real power and magnitude of voltage are specified for a generator bus and the net real power and reactive power are specified for a load bus.

For obvious reasons the net power flow to the system cannot be specified in advance at every bus because the loss in the system is not known until the study is completed. To take into account the losses and the difference of net power flow into the system, one bus, usually a generator bus is reserved and is termed a swing bus. The generator at the swing bus supplies the difference between the specified real power into the system at the other busses and the total system output plus losses. The voltage, both magnitude and angle are specified for the swing bus and the real and reactive power are a part of the solution to the problem.

The adjustments on a network analyser to obtain the desired operating conditions are in no way an easy task as the adjustment at one node affects practically all other nodes. Adjustments to each node are to be done in turn till the operating conditions are satisfied.

Changes in system operations require separate studies and if time used is to be minimised, the sequence of studies must be judiciously selected so that the changes in the system from one study to the next are minimised. Automatic adjustments rendered by servo operated units help to accelerate the task of adjustment.

2.2 SHORT CIRCUIT STUDIES ON A.C. NETWORK ANALYSER

The simplified method evolved by the A.I.E.E. committee on protective devices requires the determination of the fault currents for a three phase fault and line to ground fault which are in terms of positive sequence an zero sequence reactances of the system. These reactances are easily determined on A.C. or D.C. network analysers by setting up the actual network and applying the requisite voltages.

In case of distance and other relays, it is necessary to determine the fault current in each phase and the voltage at the relay points. This again is a very important part of the network analyser study. Such cases are analysed by representing the system based on symmetrical components or Clarke components.

2.3 STABILITY STUDIES

2.3.1 Steady State Stability

There are several criteria to test the steady state stability of the system with their various assumptions. The most important one is the calculation of $dP/d\delta$ for all generators, when a small gradual change in operating condition is made from the normal steady state values. If this ratio which can be measured on the network analyser, is positive for all generators, then the system is stable. But as a practical test if two generators which are farthest apart have this ratio positive, then the system is taken to be stable. Usually the most leading generator is advanced by a small angle δ and the most lagging one is retarded by the same amount while the other generators are left undisturbed. The ratio $dP/d\delta$ for these two machines indicate the stability or instability. Though more accurate studies involving voltage regulator and governor action may be attempted for small systems, for large systems such studies are very difficult and laborious to be done on a network analyser.

2.3.2 Transient Stability

Even with a network analyser, several simplifying assumptions are made in calculating the swing curve. The important thing required for swing curve calculations is (*a*) to establish the initial load flow conditions which entails finding the phase and magnitude of voltage behind the transient reactance of each generator, (*b*) while machines are swinging, to find the accelerating power and consequently the increase in power angle in a finite increment of time. This involves a step by step procedure.

The network analyser reduces the amount of work entailed in the calculation of a swing curve but does not obviate the necessity of making a step by step solution. Multi-machine systems involving up to twelve machine groups have been successfully analysed on Power System Analysers. Since a study of this nature is tedious and time consuming the systems to be studied are judiciously selected so that the results can be estimated for different system conditions, to some extent, by physical reasoning.

The steps involved in such a study are:—

1. The synchronous machine is represented by its transient reactance and a positive sequence system diagram drawn to a given KVA base. Equivalent machines which swing together, depending on the fault location, are grouped together. Usually after the first few swing curves it may even be possible to group them still further, thus reducing the number of machine groups with a consequent reduction in time required for the study.

2. The equivalent inertia constants of each machine group is obtained by summing up the inertia constants of each machine per the same KVA base.

3. The acceleration constants are calculated and recorded on the swing curve sheet itself and the initial magnitude and phase of all generator voltages behind the transient reactances are recorded for each machine.

4. The swing curve is started.

   a. Measurements of initial values are recorded.

   b. The change in angular displacements for the first time interval is calculated.

   c. The phase angles of machines are readjusted and the calculation continued for the next step.

The circuit changes for example, opening of circuit breaker, re-striking of the fault may be simulated on the Analyser, and the calculations are continued. The criterion for stability is whether or not all the machines return to oscillate around relative angular displacements or one or more machines pull out of step with other machine groups. This can usually be determined after a time corresponding to the swing of the machine group having the longest period.

2.3.3 Special Considerations

There are many different ways in which a system may be represented and a swing curve calculation carried out. This allows for a full play of ingenuity on the part of individuals participating. Some of the special techniques are given below:

Change in time interval:—The time interval may be changed in the course of swing curve calculations, for example, when it is evident that a larger time interval will not introduce any appreciable error. Usually the time interval should not be larger than that which allows a maximum $\Delta\delta$ of 20° for any machine group. By employing such methods the calculation time for each study may be considerably reduced.

Representation of Synchronous Condensers:—For Synchronous condensers which are known not to pull out of synchronism, they may be represented by variable shunt capacitors since it can be assumed that their phase angles are the phase angles of their terminal voltages. Negative sequence braking torque:—For unbalanced faults there may develop appreciable negative sequence braking torques and these may be accounted for by deducting the corresponding loss torque.

Additional Effects:—Additional effects such as saliency, damping excitation and governor response may be calculated to any desired degree, but ordinarily they are neglected in most studies.

Representation of Loads:—Loads are usually represented by constant shunt impedances or constant shunt impedances during fault and variable impedance after the fault is cleared. More complete representation of the loads are possible if the characteristics of the loads are known.

Small machines out of step:—When making swing-curves, occasionally small machines may pull out of step before the major synchronous machine groups have acquired any appreciable angular separation. If the machine that pulls out of step is relatively unimportant, the study may be continued with a view to study the major system.

Automation of swing curve recording:—Swing curve plotting takes considerable time and in case of Network Analysers equipped with automatic devices, the swing curves are recorded automatically thus saving considerably time.

2.4 USE OF THE NETWORK ANALYSER FOR ECONOMIC LOAD SHARING STUDIES

In order to study the economic scheduling of generators using a network analyser, it is necessary to do a large number of load flow studies and calculation of system losses, starting from the minimum generation schedule to the maximum generation schedule in incremental steps.

Analysis of one load flow problem requires considerable time and patience and a series of such studies with further loss calculation may become extremely tedious. Hence the solution of this problem is usually delegated to an Analog or a Digital Computer.

2.5 USE OF THE NETWORK ANALYSER AND ANALOG COMPUTER IN THE STUDY OF LOAD FREQUENCY CONTROL

In general, modern power systems operate at a fixed frequency. However, large load fluctuations cause frequency deviation from the normal value. The regulation of power output of various plants to compensate for this load change is a major study.

Analog computers are well suited for these types of studies and specially in the field of tie-line load frequency control studies, interconnected Analog computers and Network Analysers are used as is done at the Bonneville Power Administration.

3. DIGITAL COMPUTER METHODS

As indicated earlier, the Digital Computer has virtually replaced the Network Analyser for power system investigations. The use of the Digital Computer replaces the calculation procedure in the analyser methods resulting in great speed, accuracy and less cost of computation. Besides, problems which have never been attempted before due to practical limitations, the digital computer handles with ease.

Some of the power system problems for which the digital computer may be put to use are:—

1. Exact representation of multi-conductor networks for the analysis of high voltage transmission systems.
2. Economical scheduling of power generation.

3. Dynamic Analysis of power systems.
4. Detail models for power plants.
5. Network impedance calculation.
6. Preparation of impedance data for equipment from data files.
7. System studies such as short circuit load flow, stability and transmission losses.
8. Analysis of power line carrier communication and control.

It is to be noted that at present the use of a computer in power system studies is limited not only due to its limited availability but also due to the need of trained personnel for the computer formulation of power system problems. In spite of these limitations the digital computer has been put into use for accurate analysis of systems and the limitations on account of the number of sources, lines and other components available with a network analyser are not applicable in the case of a computer which can handle a system of any size directly or by the use of backing media.

3.1 DETERMINATION OF SELF AND MUTUAL IMPEDENCES ON A DIGITAL COMPUTER

There are a large number of power system problems in which the driving point and transfer impedances of the network are required.

They have been extensively used in system studies, such as load flow, short circuit, stability and transmission loss calculations.

The digital computer method of finding these impedances, possesses an advantage over the analog method in that it gives highly accurate values. Moreover they may be obtained economically with minimum set up time.

A number of methods are employed for such calculations of which the most prevalent are:—

a. Matrix method
b. Impressed current method
c. Iterative methods.

3.2 LOAD FLOW STUDIES

The load flow studies consist of imposing specified power input and voltage magnitude or real and reactive power input conditions at the terminals of a passive network under existing or contemplated conditions of normal operation. The solution provides complete information about

power input, voltage at the terminals and power flow in each branch of the network.

Satisfactory representation of the system depends on an advance knowledge of the effects of interconnection with other power systems, new loads, new generating stations and new transmission lines before they are actually incorporated or installed.

For any normal power system network the nodal equation can be written as

$$I_k = \sum_{N=1}^{N} Y_{km} E_m$$

Where E_m presents the complex voltage at the nodes,

I_k the complex current flowing into the nodes,

Y_{km} are the complex nodal admittances.

Then the power equation for any node 'k' could be stated as

$$P_k + jQ_k = I_k^* E_k$$

Where I_k^* is the conjugate of I_k

P_k is the real power and

Q_k is the reactive power into the network at node k

This equation is solved for each node satisfying the given conditions for that node.

Different approaches are available for the solution of the power flow problem. Of these, some are described below.

3.2.1 Iteration Method (Ward & Hale)

In this method, voltages are assumed for each bus whose voltage is not specified. Next with the assumed set of voltages the power input to each bus is computed and the difference of the scheduled power, the calculated power and the corresponding necessary correction is computed from the set of linearised difference equations. This process of finding the difference of power and voltage correction proceeds till difference of power falls within the permissible error.

3.2.2 Iteration Method (Glimn & Stagg)

In this method a set of voltages for the nodes are first assumed. Then for a general node p, E_p is calculated using the equation

$$E_p = \frac{\dfrac{P_p - jQ_p}{E_p^*} + \sum_{q=1}^{n} y^{pq} E_q}{\sum_{q=1}^{n} y^{pq}} \qquad \text{where } q \neq p$$

In case of generator buses Qp has to be calculated using the equation

$$Q_p = \text{Imag}\left[\left\{E_p \sum_{q=1}^{n} y^{qp} + \sum_{q=1}^{n} y_{pq} . E_q\right\} E_p^*\right]$$

since Q_p is not specified. where $q \neq p$

Having calculated the voltage, it is reduced proportionately to correspond to the magnitude requirement. This process of iteration is carried out till two consecutive computations differ by a value less than the permissible error. Acceleration factors may be used to reduce the number of iterations.

Once the voltages have converged to the desired precision the power flow in each branch can be calculated from the equation

$$P_{pq} + jQ_{pq} = E_p\left[\left(E_p - E_q\right)^* \left(-y^{pq}\right)^*\right]$$

3.2.3 Impedance Matrix Iterative Method

In this method initial currents are assumed and the voltages are computed using the transfer impedance matrix. Terminal condition errors are determined and the initial currents are corrected to give new values to start the next iteration.

This program essentially consists of three subroutines namely,

1. Matrix formation subroutine
2. Data sorting and modifying subroutine
3. Iteration subroutine.

3.3 SHORT CIRCUIT STUDIES ON DIGITAL COMPUTER

The methods that are available for short circuit studies can broadly be classified into:—

1. A nodal iterative approach
2. Driving point and transfer impedance approach.

3.3.1 Nodal Iterative Method

The general expression for the source current towards node 'k' of a network having N independent nodes, i.e. N buses other than the neutral is given by

$$I_k = \sum_{n=1}^{n} y_{kn} V_n$$

Where I_k is the current entering the node k

Y_{kn} is the admittance of the line connecting buses k to n

V_n is the n th bus voltage.

In this equation off nominal transformer ratios and mutual impedance could be considered, where necessary.

The above equation could be written for each bus at which the voltage is unknown. N may include the node between the internal e.m.f. of a machine and its internal reactance. The voltage of the faulted bus is assumed zero and all internal voltages are computed from a load flow study or the voltage of the faulted bus is assumed equal to Vf if the load current is to be neglected. Therefore, equations are required only for the nodes where current entering the network is zero. Then the above equation could be written as

$$O = Y_{kk} V_k + \sum_{n=1}^{n} Y_k V_n$$

Where $n \neq k$

Initial values are assumed for all unknown voltages and the correct values are computed by iteration, till the desired accuracy is reached.

3.3.2 Driving Point and Transfer Impedance Method

This method requires the calculation of a matrix called the short circuit matrix for the whole network. The advantage of this method is that once the matrix is found, all fault calculations may be done within minimum arithmetic operations involving only the related portions, whereas in the nodal iterative method iterations are necessary for each bus of the entire network.

Unbalanced faults can be analysed by this method where

1. A network element is represented by a 3 × 3 submatrix.
2. A bus voltage is represented by a 3 × 1 vector.

3.4 TRANSIENT STABILITY STUDIES ON DIGITAL COMPUTER

The following methods are commonly used in transient stability of a power system.

1. Equal area criterion method (Analytical)
2. Step by step method (Numerical and graphical)
3. Network analyser method (analog)
4. Numerical Integration (Digital)

Of these the Numerical Integration method is employed for stability studies using a digital computer.

The stability characteristics of a power system during transient disturbances are analysed by its mathematical model, namely the set of non-linear differential equations with constant coefficients, provided constant voltage behind the transient reactance and constant input to the machines are assumed.

The solution of these equations gives the swing curves which indicate whether the system is stable or unstable. If these curves show that the angle between any two machines tends to increase without limit, then the system is unstable. If on the other hand, the angle between any two machines reaches a maximum value and thereafter decreases, it is probable, although not certain, that the system is stable.

There are several numerical methods to solve the set of non-linear differential equations of which the Runga Kutta method is the most commonly used. The Runga-Kutta method with fourth order correction has an error of $(\triangle t)^5$ where $(\triangle t)$ is the incremental time used in the integration. Accuracy may be improved by the selection of a smaller incremental time.

Modifications, to take into account the effects of fast acting voltage regulators, and governors may be built into the mathematical model to obtain a more realistic solution of the swing curve.

Another method of determining the stability of the equilibrium without going through the rigour of solution of the differential equations has also been developed. The stability is established with the aid of a suitably constructed Liapunov's function for the system. The extent of this stability specifies the region of all initial conditions around the equilibrium state for which the system is asymptotically stable.

3.5 ECONOMIC SCHEDULING OF GENERATION BY A DIGITAL COMPUTER

The economic scheduling of power involves the following steps:—

1. Preparation of Data (Electrical System and Plant data)
2. Determination of Transmission loss formula
3. Evaluation of saving by considering transmission losses in the scheduling of generation.
4. Application of coordination equations to Power System operation.

Determination of transmission loss formulae involves the following steps:—

a. Resistance measurements on open circuited transmission network

b. Base case load flow data

c. Calculation of loss formula coefficients.

All the above calculations can be done on the digital computer.

The resistance matrix can be formed by finding the open circuit self and mutal impedances of the system and the base case load flow is obtained by a load flow study on the Computer.

After the loss coefficients are evaluated, the next step would be to solve coordination equations necessary for carrying out steps 3 & 4. This is performed as follows:—

Generation schedule is determined by the solution of the coordination equations.

$$\frac{dF_n}{dP_n} + \lambda \frac{P_1}{P_n} = \lambda \quad \text{for different values of } \lambda$$

Then the cost of power by each schedule that satisfies either total generation or total received power, is determined and the schedule that gives the minimum cost is considered as the economic solution.

Different methods are available for the solution of the coordination equations and the solution by iteration as described below is considered to be the most favourable method of solution.

The coordination equation is given by

$$\frac{dF_n}{dP_n} + \lambda \frac{\partial P_L}{\partial P_n} = \lambda$$

Where $\left(\frac{dF_n}{dP_n}\right)$ is the incremental production cost of plant n,

$\frac{\partial P_L}{\partial P_n}$ is the incremental transmission loss at plant n,

λ is the incremental cost of received power.

$\frac{dF_n}{dP_n}$ could be expressed by the equation

$$\frac{dF_n}{dP_n} = F_{nn} P_n + f_n$$

Where F_{nn} is the slope of the incremental production cost curve and f_n is its intercept.

Also $\frac{\partial P_L}{\partial P_n}$ could be expressed

$$\text{as} \quad \frac{\partial P_L}{\partial P_n} = \sum_m 2 \text{ Bmn Pm.}$$

Then the coordination equation could be expressed by

$$F_{nn} P_n + F_n + \lambda \sum_m 2 B_{mn} P_m = \lambda \quad \text{which could be written}$$

in the form

$$P_n = \frac{\frac{1 - f_n}{\lambda} - \sum_m 2 B_{mn} P_m}{\frac{F_{nn}}{\lambda} + 2 B_{nn}} \qquad m \neq n.$$

From this equation, iterations could be performed for P_n using one particular value of λ till the value of P_n converges to a desired precision, thus giving the generation schedule.

LECTURE TO SECTION D

BLUE-GREEN ALGAE AND SOIL FERTILITY

by

G. E. FOGG, F.R.S.

Supply of combined nitrogen is often a factor limiting the biological productivity of an environment and it is well recognized that those organisms which are able to fix (or bring into combination) the free nitrogen of the atmosphere have an important part to play in maintaining or increasing fertility. At the end of the last century when investigation of these matters got under way, many authorities considered that the blue-green algae (Myxophyceae) were particularly valuable in this respect. Thus, it is interesting to note that the famous paper in which Beijerinck (1901) described isolation of nitrogen-fixing bacteria of the genus *Azotobacter* was actually primarily concerned with the blue-green algae, which unfortunately he was not able to study properly because he could not isolate them in pure culture. Now, it is well established that many blue-green algae are indeed capable of nitrogen fixation but the general view has been that, except in special situations such as paddy fields, they do not contribute much to soil fertility. This view has perhaps arisen partly as a historic accident, because by 1928, when Drewes reported the first unequivocal evidence for nitrogen fixation by blue-green algae, the bacteria *Azotobacter*, *Clostridium* and *Rhizobium* (in association with legumes) were firmly established with most biochemists and agriculturalists as the only nitrogen-fixing micro-organisms. However, as I hope to show in this lecture, the evidence now points to the blue-green algae making a substantial contribution to soil fertility by nitrogen fixation.

Definite proof of ability to fix nitrogen has been published for some forty species of blue-green alga (see Stewart, 1966, for references) and one may hazard the guess that about half the described species of Myxophyceae possess the property. In terms of number of nitrogen-fixing species, then, the blue-green algae probably far exceed any other group of micro-organisms. To this one may add that they are widespread and abundant in a wide variety of different kinds of habitat.

Next one may consider the probable effects of certain key factors on their nitrogen-fixing activity in soils. Light is perhaps the most important here because nearly all the blue-green algae investigated are obligate photographs, that is to say they can only grow photosynthetically and not at all in the dark, even if sugars or other substrates are provided. *Chlorogloea fritshii* (Fay, 1965) and *Tolypothrix tenuis* (Kiyohara, Fujita, Hattori and Watanabe, 1960) are exceptions to this rule but it does not appear that suitable substrates are available in sufficient concentration naturally in soil to permit appreciable growth of such species in the absence of light. It seems then that effective growth and nitrogen fixation by blue-green algae must be confined almost entirely to the soil surface. Against this limitation must be set the great advantage which independence of a supply of organic matter gives. It is generally found that the nitrogen-fixing activity of heterotrophic bacteria such as *Azotobacter* is only appreciable when a suitable organic substrate is artificially supplied to the soil. Some calculations of rates of fixation in a lake of 2.6 hectares area (Kusnezow, 1959), illustrate how very much greater the potentialities of the photosynthetic nitrogen-fixer may be; the total fixation by *Azotobacter* during the summer season was estimated as 0.14 g as against 13.1 kg for the blue-green alga *Anabaena*.

Nitrogen fixation is inhibited if a source of combined nitrogen is available to the organism, completely if an ammonium salt is supplied but often only partially if the nitrogen source is nitrate or an organic substance. The concentrations of available combined nitrogen in soil are usually such as to be inhibitory. However, because of the heterogenous structure of soil and the slowness of hydro-diffusion, the supply in the immediate vicinity of an actively growing algal colony will be depleted rapidly. When this happens, free nitrogen, the diffusion of which in the gas phase is many thousand times more rapid than the diffusion of dissolved nitrogenous compounds in the soil, will become the most accessible source. It is to be expected therefore, that, except in water-logged conditions, nitrogen fixation will take place even in fertile soils.

One of the specific requirements of nitrogen-fixing organisms is for the trace element molybdenum. In culture blue-green algae require about 0.1 parts per million of molybdenum in order to fix nitrogen at maximum rate. Soils in various parts of the world are recognized as being molybdenum deficient and it seems possible that nitrogen-fixation is often limited by lack of this element. It would seem well worth while carrying out field trials of fertilization with molybdenum, which could be cheap since such small quantities are needed, on any agricultural soil in which blue-green algae occur in appreciable numbers.

If we are to assess the actual contribution of blue-green algae to soil fertility, we need first of all to know a great deal more about the distribution of nitrogen-fixing species. Fortunately a simple means of recognizing these species without taxonomic identification or biochemical demonstration of nitrogen fixation is available. All the nitrogen-fixing species so far known possess the curious empty-looking cells with thick refractive walls known as heterocysts, and no heterocystous blue-green alga has been found which has not proved able to fix nitrogen. An apparent exception to this rule was *Chlorogloea fritschii*, which, although described as a unicellular form and therefore not possessing heterocysts was nevertheless found to fix nitrogen. Further investigation showed that this *Chlorogloea* is a reduced filamentous form, probably a *Nostoc*, and that it develops heterocysts at certain stages of growth (Fay, Kumar and Fogg, 1964). Heterocysts are not developed when combined nitrogen is readily available in the form of an ammonium salt and their abundance shows an inverse relationship to the amount of combined nitrogen in the cells. The question arises as to whether heterocysts are directly concerned in nitrogen fixation. Preparations of isolated heterocysts have however been reported to have no nitrogen-fixing or photosynthetic activity although they respire at a higher rate than normal cells. Possibly the right conditions for nitrogen fixation were not provided in these experiments and it seems worth while making further attempts to investigate them from this point of view. Meanwhile the strict correlation between the presence of these structures and the ability to fix nitrogen can be used as a means of assessing the potential nitrogen-fixing activity of an algal sample by workers with little more than a superficial knowledge of the taxonomy of the Myxophyceae. A world-wide survey of the distribution of nitrogen-fixing blue-green algae is being organized on this basis by Dr. W. D. P. Stewart of Westfield College, London, under the auspices of the International Biological Programme.

Secondly we need much more information about actual rates of fixation in the field. This is not an easy matter; it is difficult to obtain representative samples of soil and vegetation and the combined nitrogen content of the material is high, so that the small gains due to fixation over periods of a few days or weeks are generally statistically insignificant. In fact determinations of total nitrogen by a method such as that of Kjeldahl are usually only feasible with pot experiments.

The most satisfactory method from the point of view of accuracy is that using the heavy isotope of nitrogen, 15_N, as a tracer. Unfortunately the radio-active isotope of nitrogen, 13_N, has too short a half-life to be of any use and, 15_N being stable it has to be assayed with a mass-spectrometer. The essence of the method as used by Stewart (1967a) is to enclose a sample of soil or plant material in a flask in which the air is replaced by an artificial gas mixture enriched with 15_N, a buffer being provided to maintain a supply of carbon dioxide. The flask is exposed *in situ* for a suitable period—usually 24 hours—then the sample is analysed for its total nitrogen and 15_N contents. From these, with suitable corrections to allow for temperature differences inside and outside the flask and for any differences in partial pressure of nitrogen, the rate of nitrogen fixation may be calculated. Using this method Stewart (1965) has demonstrated that in sand-dune slack (a low-lying marshy area occasionally inundated by the sea) on the east coast of England, fixation of nitrogen is largely confined to the upper centimetre of the soil and parallels the distribution of the heterocystous blue-green algae. Furthermore fixation was only appreciable in the light. In this situation therefore blue-green algae were certainly the main nitrogen-fixing agents. The rates observed corresponded to 7.1 lbs. of nitrogen fixed per acre per month when the samples were taken at random and 18.2 lbs. per acre per month when samples were taken from spots with obviously rich algal cover. Fixation was found to take place for eight months in the year, being nearly zero in the colder winter months and low in the summer, presumably when drying out occurred, (Stewart, 1967). In this rather unpromising situation, then, nitrogen fixation was surprisingly vigorous and although the amounts contributed are less than the 200 lbs. per acre per year that may be fixed by a good leguminous crop, they are nevertheless sufficient to make an appreciable difference to fertility. Results obtained in the Antarctic using the same method are reported in another paper in this volume (see p. 263) Again, blue-green algae appeared to be the only agents fixing appreciable quantities of nitrogen and their activity was much higher than expected. No results using the 15_N technique appear to have been reported for tropical soils.

15_N is expensive, the cheapest available 15_N-enriched substances costing about £30 per gram at present, and the equipment needed for its assay is elaborate and costly. These factors militate against the use of the 15_N method on a large scale. Fortunately there is prospect of a much cheaper and more rapid method becoming available. This depends on the fact that nitrogen-fixing organisms will accept acetylene (CH ≡ CH) instead of nitrogen, and reduce it to ethylene. Samples are exposed *in situ* in small bottles in which the atmosphere contains a proportion of ethylene. After a suitable period, which may be as short as 5 or 10 minutes, a gas-sample is withdrawn and analysed for ethylene by gas chromatography. Production of ethylene is definite evidence of nitrogen fixation and there is a reasonable supposition, which has not, however, been proved rigorously as yet, that the rate of production is in direct proportion to the rate of nitrogen fixation. A variety of samples has been examined by this method, including a Wisconsin soil, in which low rates of fixation, presumably by heterotrophic bacteria, have been demonstrated, as well as much higher light-dependent rates associated with the presence of blue-green algae (Stewart, Fitzgerald and Burris, 1967).

As far as they go these facts show that blue-green algae are more active in nitrogen fixation in temperate soils than has been thought possible in the past. It seems likely then that their contribution to the fertility of tropical soils, for some of which their importance has been recognized for some time, may often be very considerable indeed and in conclusion we may look briefly at one tropical situation in which blue-green algae may be outstandingly important—the paddy field. Blue-green algae are not always abundant in paddy-fields, perhaps because low pH or availability of phosphate are limiting, but the common occurrence of nitrogen-fixing species has been amply documented (for references see Stewart, 1966). In pot experiments rates of fixation corresponding to as much as 40 pounds of nitrogen fixed per acre per year have been demonstrated. It would be most interesting to see what is actually achieved *in situ*, using either the 15_N or acetylene techniques. It has been shown using 15_N as a tracer that uptake of nitrogen fixed by blue-green algae into higher plants is relatively rapid (Stewart, 1967) so that the benefit to the rice plants may be direct. Accepting the results of pot experiments as giving a rough idea of the magnitude of the blue-green algaes' contribution, it is clear that in paddy fields which do not receive fertilizer their presence may make all the difference between a moderate crop and a very poor one. It seems well worth while devoting more research effort to seeing how this contribution can be increased.

References

BEIJERINCK, M. W. (1901). Ueber oligonitrophile Mikroben. *Zbl. Bakt.*, Ser. II, **7**, 561-582.

DREWES, K. (1928). Über die Assimilation des Luft-stickstoffs durch Blaualgen. *Zbl. Bakt.*, Ser. II, **76**, 88-101.

FAY, P. (1965). Heterotrophy and nitrogen fixation in *Chlorogloea fritschii. J. gen. Microbiol.*, **39**, 11-20.

FAY, P., KUMAR, H. D. and FOGG, G. E. (1964). Cellular factors affecting nitrogen fixation in the blue-green alga *Chlorogloea fritschii. J. gen. Microbiol.*, **35**, 351-360.

KIYOHARA, T., FUJITA, Y., HATTOR, A. and WATANABE, A. (1960). Heterotrophic culture of a blue-green alga, *Tolypothrix tenuis* I. *J. gen. Appl. Microbiol., Tokyo*, **6**, 176-182.

KUSNOZOW, S. I. (1959). *Die Rolle der Mikro-organismen im Stoffkreislauf der Seen.* Deutscher Verlag der Wissenschaften, Berlin.

STEWART, W. D. P. (1965). Nitrogen turnover in marine and brackish habitats. I. Nitrogen fixation. *Ann. Bot.*, N.S. **29**, 229-239.

STEWART, W. D. P. (1966). *Nitrogen fixation in plants.* University of London: Athlone Press.

STEWART, W. D. P. (1967a). Nitrogen turnover in marine and brackish habitats. II. Use of 15_N in measuring nitrogen fixation in the field. *Ann. Bot.*, N.S. **31**, 385-407.

STEWART, W. D. P. (1967b). Transfer of biologically fixed nitrogen in a sand dune slack region. *Nature*, **214**, 603-604.

STEWART, W. D. P., FITZGERALD, G. P. and BURRIS, R. H. (1967). In situ studies on N_2 fixation using the acetylene reduction technique. *Proc. Nat. Acad. Sci., Washington*, **58**, 2071-2078.

POPULAR LECTURE

MEDICAL EDUCATION

by

SIR MAX ROSENHEIM, P.R.C.P.

In the garden of the beautiful new building of the Royal College of Physicians of London have been planted two plane trees which, we are assured, are lineal descendants of the great plane tree on the island of Cos, off the Greek Coast, under which, some 2,500 years ago, Hippocrates sat and taught medicine to his students.

I want, this evening, to discuss some of the problems that, today, face those interested in the training of doctors, for the vast increase of detailed knowledge, the extending scope of medical science and the increasing demand for medical care have made a review of the aims and methods of medical education essential. In Great Britain we have a Royal Commission on Medical Education sitting under the chairmanship of Lord Todd, and we hope that this Commission will show us how to solve some of the intricate problems that I am about to lay before you.

The teaching of medicine was, until fairly recent times, based almost entirely upon the apprentice system; students being attached to physicians and surgeons, helping in the wards and picking up words of wisdom as they dropped from their lips.

As our understanding of anatomy and physiology and later of biochemistry and pharmacology increased, the medical school as we recognise it today became established, with preclinical and clinical sections. This organisation of teaching unfortunately raised a barrier, fortified by a stiff examination, between what were then regarded as the purer or basic sciences and the clinical teaching in the wards. During the first few decades of this century, while clinical medicine remained to a large extent a craft, teachers of physiology and anatomy claimed that they had to give medical students a scientific education and critical outlook before they became exposed to the uncritical empiricism of the clinical teachers. This was the state of affairs when I was a student.

The situation at the present time has altered in many respects. First of all physiologists, biochemists and pharmacologists are increasingly engaged in intricate and often esoteric research; the physiologist exploring the mysteries of the nervous system; biochemists unravelling the details of metabolic cycles and pharmacologists investigating the mode of action of synthetic chemicals on animal tissues. They are often not medically qualified and, in England, may be more concerned with the training of their B.Sc. and Ph.D. students than with the education of medical students.

On the other hand it is now generally recognised that many of the great advances in human physiology, in our understanding of the normal working of the human body, are coming from the clinical laboratories. Clinical science is now a science in its own right and modern methods of clinical investigation of the sick have thrown new light on the normal working of the heart, lungs, kidneys, liver and endocrine glands.

With this growth of clinical science, and with the advances in pathology and microbiology, the teaching of clinical subjects is more and more based on a clear understanding of the underlying functional and structural abnormalities, on the causation of the disorder and on specific and highly effective methods of treatment.

And yet, today, the barrier of the second M.B. examination, that has to be passed before the student can start his clinical work, and the domination of the physiologist, anatomist and biochemist over the biochemist over the early years of medical education form a major obstacle to the reorganisation of the medical curriculum. At the same time, there have sprung up new disciplines and the medical student today should learn about such vital subjects as genetics, normal and abnormal psychology, sociology, statistics, epidemiology and community health. Furthermore they should receive instruction in some of these subjects early in their training.

It must be admitted that there are also faults in the clinical field, for here we have seen the growth of specialisation, an unavoidable development with the greater understanding of disease and the more skilled and intricate methods of investigation and of treatment both medical and surgical. Thus, for instance, we now have the cardiologist, the neurologist, the haematologist and, on the surgical side, the orthopaedic surgeon, the neurosurgeon and the plastic surgeon. Such specialisation is contributing greatly to our knowledge and is of the greatest benefit to patients but there is a tendency for each specialist to burden the poor student with too much detail, until there is grave danger that the overloaded curriculum may sink beneath the added load of specialised knowledge.

Clearly the time is ripe for a review of medical education. We must look at what we are trying to achieve and must aim at a more integrated and yet simplified curriculum.

We must accept that the student cannot possibly learn everything and we must aim at turning out doctors who have acquired a critical and scientific approach, who have an understanding of basic physiological and pathological processes, who have learnt how to use a library and know where to turn to for further information and help. Even if the young doctor could, on qualification, know a great deal about each of the specialties, he is going to be faced during the forty years of his career as a practising doctor with tremendous new advances, with new concepts of disease, new methods of investigation and new lines of treatment. It was Dr. Berry, when Dean of Harvard Medical School who, addressing the new intake of medical students, told them that in ten years time half of what they were going to be taught would have been shown to be wrong and that, unfortunately, none of their teachers knew which half.

One of the great attractions of medicine as a career is the fact that, once qualified, there is a very wide choice of future activities. The young doctor may go into general practice, he may aim at becoming a consultant in one of the many specialties, he may prefer laboratory life and become a pathologist, bacteriologist or physiologist, he may decide to become a psychiatrist, an obstetrician, a public health expert or an administrator.

Medical schools must, therefore, aim at turning out a good general doctor who, only after qualification, will select his future career and who will certainly then require further vocational training.

This basic doctor must not just be stuffed with facts. Medicine must not become a technology. The student must learn about the world in which he lives, he must know how his patients live, what their problems may be in their families and in the community and he must appreciate the many facets of medical care. Scientific training must not stifle his original aim at helping the sick and, to his end, he should, during his period of education, get outside the hospital ward into the homes, the factories and the schools, he must learn something of sociology and epidemiology and must appreciate the tremendous contributions that

public health and preventive medicine are making to the health of the community. The overloaded curriculum must be lightened. Preclinical and clinical teachers need to get together and agree on how much should be taught. The barrier of the 2nd M.B. needs to be lowered, so that the student early in his career can see patients and learn the application of his basic knowledge to the care of the sick. Integrated teaching with clinicians taking part in physiology or biochemistry seminars and the preclinical sciences spreading into the clinical discussion groups would help to make a much better basic course. Throughout their career, students should also receive training in the social sciences, in psychiatry, genetics and epidemiology.

He would then receive a liberal University education. Each student should, at some stage, be free to pursue some topic in which he was especially interested during an elective period. The better students should continue to be encouraged to spend an extra year, interpolated during their course, to delve more deeply into one subject, reaching and appreciating the limits of knowledge and gaining some understanding of how research is gradually widening the frontiers. Such students should be able to obtain a B.Sc. degree in a preclinical, pathological or clinical subject during their undergraduate training.

If students are to appreciate the constant changing face of medicine, if they are to be prepared critically to assesss and adopt the developments of future years, teaching must not be didactic. They must never be led to believe that everything is known about a subject or that either their text-books or their teachers know all the answers. Rather they must be encouraged to think things out for themselves, constantly seeking for reasons for statements that are made and expecting their teachers to admit that they often do not themselves know. This is why small group seminars and discussion groups are so much more stimulating than set lectures such as this one! May I quote from the Lancet of 150 years ago:—

> "... To attempt to learn by lectures only is idle and unprofitable; take them as guides to direct your observation, your reading, your meditation; but to suppose that the mere listening to lectures should confer excellence would not be less futile than for a traveller to bestride a guide-post and vainly expect that it should, without effort on his part, convey him to the destination to which it points".

Students should, as far as is possible, be brought up in an atmosphere of research and should appreciate that at least some of their teachers are engaged in trying to extend knowledge, whether by simple clinical and epidemiological observation or by the more intricate methods of modern laboratory investigation. They must learn to think of medicine as a living, constantly developing, body of knowledge.

The student, qualified as a good general doctor, must appreciate his limitations and the need for vocational training before he will be ready to practice in whichever sphere of medicine he chooses and the need to keep abreast of modern developments. It was William Osler who wrote:—

"The hardest conviction to get into the mind of a beginner is that the education upon which he is engaged is not a college course, but a life course for which the work of a few years under teachers is a preparation".

The medical curriculum then, the undergraduate teaching programme, must be constantly changing and, in every school, a curriculum committee should try to prevent the addition of new burdens to the students' load without it being lightened in some other direction. There should be frequent and free discussion among the teachers aiming at the increased integration of teaching.

In Great Britain the General Medical Council has the statutory duty of the supervision of medical education and, under the Medical Act of 1858, must ensure that persons placed upon the Medical Register possess "the requisite knowledge and skill for the efficient practice of their profession". The Council exercises its right to visit and inspect Medical Schools and their examinations and accepts the degrees of recognised schools for admission to the register. I understand that Ceylon has recently had such a visit that has resulted in the recognition by the G.M.C. of the Medical School in Peradeniya. This is a great step forward and I congratulate the University, the Dean of the Medical School and all the teachers—and of course the students.

The General Medical Council periodically reviews the curriculum and publishes its Recommendations for the Guidance of Medical Schools. Their latest "recommendations" were published this year. These show a great appreciation of the difficulties of modern medical education, have further liberalised the curriculum and encourage every medical school to experiment in its teaching.

The Council suggests that medical education can be divided into a series of recognisable periods:—

a. The period of pre-medical studies,

b. The period of Basic Medical Education, which includes the so-called preclinical, clinical and pre-registration periods of study,

c. Vocational training for a particular career in medicine and

d. Continuing education thereafter for all doctors.

The Council believes, and I am sure that they are correct, that in medical education there should continue to be a single objective for all doctors up to the time of full registration, whatever their final career. If I may quote their recommendation:—

"The object of this basic medical education should therefore be to provide doctors with all that is appropriate to the understanding of medicine as an evolving science and art, and to provide a basis for future vocational training; it is not to train doctors to be biochemists, surgeons, general practitioners or any other kind of specialist".

In 1957 the Council emphasised the need for reducing the students' factual load and for ensuring, and I quote again:—

"that the memorising and reproduction of factual data should not be allowed to interfere with the primary need for fostering the critical study of principles and the development of independent thought".

In 1950 the Council introduced the compulsory pre-registration year, a year of practical clinical work, as house physician or house surgeon, which each student had to undertake after passing the qualifying examination before his name could be placed upon the Medical Register and he became free to practice medicine wherever he wished. It was hoped that this preregistration or intern year would evolve into a period in which the young doctor, acquiring responsibility under supervision, learnt the skills of his profession and the application of principles learnt as a student. Unfortunately in England, in many instances, the young doctor has been overworked and under-taught and the preregistration year has been much criticised. The selection of suitable junior posts is the duty of the University, for the final report which allows the graduate to be registered must be signed by the Dean of the Medical School. The facilities of these posts, the amount of teaching that the interns receive, the number of beds in their charge, the availability of a library and the availability of supervision all need watching. In these, as in other junior training posts, service needs must not crowd out the educational aspects.

Before leaving the subject of undergraduate medical education, let me emphasise the need for the student to be given instruction and to learn about Medical Ethics, about the problems of medicine in industry, about family planning and child welfare and other problems of Community Medicine. He must get outside the hospital and learn that medicine is not only concerned with the sick patient in a hospital bed.

Postgraduate Medical Education

Let us now pass to consideration of postgraduate medical education; first of all "vocational training" that prepares the doctor for his life work and then the "continuing education" that every doctor must receive if he is to keep abreast of modern thought and practice.

The newly qualified and registered doctor, who has been watched, advised and guided through his undergraduate years, is unfortunately thereafter often left to fend for himself, to map out his own career until he has obtained sufficient seniority to acquire an established post in the field in which he wishes to work.

In Great Britain postgraduate medical education has been somewhat disorganised and is, at last, coming under review. The further education of the future consultant and, in the future we hope also of the general practitioner, must take place while holding junior hospital appointments in the National Health Service. Here, of course, service needs, the duties and work load of the posts, compete with the need for the young men to acquire further knowledge in a systematic manner. Registrar and Senior Registrar posts are recognised as training posts, but, in many places, the doctor gets very little time for reading, for attending lectures or seminars or study leave to attend special courses. Furthermore the junior hospital officer has to compete every year or so for the next post and may be unable to pursue the direct course that he wishes to follow. Too much time is spent in junior posts and our consultants are appointed at too old an age.

In the United States and Canada, the intern and residency programmes do, to a greater extent, provide a set period of years of increasing responsibility for those selected for higher training, while each hospital organises a full programme of discussion rounds, seminars, clinicopathological conferences and other similar projects, usually under the direction of a senior member of the staff.

In November 1966, a large conference on postgraduate medical education was organised at the Royal College of Physicians, to which were invited representatives of all the interested bodies, including the recipients of postgraduate training, the young doctors themselves.

While the Universities are especially responsible for the training in the preclinical and preregistration years, they are also concerned with higher degrees such as the M.D. and M.S. The Royal Colleges are especially interested in the maintenance of high standards of knowledge and practice and in vocational and specialist training, though they must also necessarily be concerned with the earlier years as well. There is clearly much overlap and, at the instigation of Sir Robert Aitken, the medically qualified Vice-Chancellor of the University of Birmingham, the Colleges and the Universities in the United Kingdom have come together to form the new Central Committee for Postgraduate Medical Education. This Committee is still finding its feet, but it is being supported for the first five years by the Nuffield Provincial Hospitals Trust, has acquired a whole time secretary and staff and is now beginning to review the needs and methods of vocational training.

Many of us believe that a much better co-ordinated scheme of training for the various specialties can be devised and that a young graduate once selected for training, should be a marked man, whose progress is watched and carefully assessed and that, if he makes good, he should be able to reach consultant status by the age of 32-34. Since the number of consultant posts in the various specialties is limited, it should be possible to bring the number of junior training posts into line, so that we train the right number for each specialty and avoid the frustrations that have, of recent years, tended to encourage many of our young men to emigrate to the United States, Canada or Australia.

Underlying such vocational training must be the concept of competition. Selection must be made the basis of promotion; selection based on assessment of performance, on the results of higher examinations, on evidence of research, teaching or other special interests. As the young man slowly, and sometimes painfully, climbs the pyramid to the higher ranks in the profession, he must feel that his work is always under review at that intelligence, efficiency and hard work will reap reward.

This is achieved, at present, in the United Kingdom by the advertisement of vacant posts and by the selection of the most suitable candidate by special advisory appointment committees. All appointments from those of registrar upwards are made by committees, the composition of which varies according to the seniority of the post.

One of the more unfortunate relics of colonialism persisting in Ceylon is that of promotion by seniority—a relic of army practice. If the best young men are to reach the top and in due course gain consultant posts in teaching hospitals, so that future doctors receive the best training, some scheme of selection on merit appears to me to be essential.

I must say something about postgraduate degrees and diplomas. The M.D. degree in London University is now awarded on a thesis that reports original work. If the candidate has worked in hospital as a registrar and senior registrar or on a Medical Unit, a thesis with evidence of active laboratory work is expected, but if he is in General Practice he must wait longer before submitting his thesis, which will not be expected to embody so much laboratory work, though still recording original observations.

We regard success in the membership examination of one of the Royal Colleges as indicating that the doctor has acquired a wide knowledge of general medicine and that he is now ready for specialist training, as a Senior Registrar in general medicine, cardiology, chest diseases, gastro-enterology or other subject. Our College has produced recommendations for training schemes in the various specialties and is just beginning to prepare a list of recommended posts; posts regarded as suitable for specialist training.

Your M.D. is still awarded on the results of a very searching examination and having acted as external examiner here on two occasions, I hold your M.D. in very high regard. It is, in fact, of a standard very similar to our London Membership and, since you have tried to restrict those sent overseas for further study in medicine to those who have acquired your doctorate in medicine, it is not surprising that your young

men do so well in the membership examination. The pass lists at each examination usually contain a number of Ceylon names. This is impressive and excellent.

If indeed your M.D. equates well with our Membership, it should not really be necessary for those whom you send to the United Kingdom for further training to spend much time on acquiring an M.R.C.P. This often involves them in attending special courses or holding junior hospital posts in non-teaching hospitals. It would surely be better, both for your graduates and for your medical services, if your best graduates were sent overseas for some specific specialist training, so that the future consultant and specialist spent 2-3 years working in a special unit, learning in detail the methods of investigation, diagnosis and treatment and perhaps joining in some research projects. Such newly acquired specialist knowledge should stand him in better stead on his return to Ceylon than further letters after his name, provided that a post is available for him to practice the specialty that he has learnt.

We hope, in the future, to discourage young men from the over-active chase for diplomas. Discussions have already started between the London College and the Royal Colleges in Edinburgh and Glasgow on the possibility of holding a common Part I for the membership examination, in the form of a multiple choice paper. I should ultimately like to see a common diploma examination for the membership of all three colleges. There are, of course, many difficulties here, but the advantages would be very great.

In this context, I was delighted to learn of the establishment of the Ceylon College of Physicians and am sure that this body will play a most important role in maintaining the standards of practice in medicine, in supervising postgraduate education in the medical specialties and in offering expert advice on medical topics to many bodies. From the Royal College of Physicians of London, I greet the Ceylon College of Physicians, wish it a most successful future, being confident that the two Colleges will work together in great amity and concord for the better future of medical practice and education.

Finally I wish to say a little about "continuing education". By this is meant an organisation through which practising doctors, be they consultant physicians, surgeons, obstetricians or general practitioners, are kept up-to-date. In a country which has a Government Medical Service or a National Health Service, it is vitally important to keep all doctors in the service practising the best of modern medicine, with knowledge of recent advances in investigation and treatment. If one accepts an analogy with a large and expanding business, it must surely be the duty of the service to arrange such continuing education.

This is actually happening in the United Kingdom. During the past few years, stimulated by a conference called by the Nuffield Provincial Hospitals Trust, there has been growing appreciation of the need for such continuing education and small post-graduate institutes are springing up all over the country, attached to the major district hospitals. There are now more than 80 of such institutes.

Each institute contains a good lecture theatre with all ordinary demonstration facilities, a library and reading room and a common room where tea and coffee can be obtained. Such institutes provide a stimulus to teaching, and case presentations, discussion groups, lectures and journal clubs flourish. Lectures or case demonstrations are given at regular times for the local general practitioners; while lectures for the junior hospital staff are given by the senior staff or visiting lecturers from teaching hospitals. This is a most exciting development.

The junior staff, registrars and senior registrars, are also given time off to attend special courses, while the senior staff attend conferences on special subjects organised at the Royal Colleges.

This then is the developing pattern of medical education and, as I hope that I have shown you, we, in the United Kingdom, are making great efforts to bring our educational methods up-to-date. We are striving to produce general practitioners who have had special vocational training and who are given the facilities for practising really good medicine outside the hospital. We are planning special programmes for the onward training of our future specialists and we recognise that post-graduate education, both vocational and continuing, is essential if doctors are to pass on to their patients the most recent advances in knowledge and if they, themselves, are to avoid frustration and retain their self-respect in the best and satisfying practice of this wonderful and fascinating profession.

POPULAR LECTURE

BOTANIST IN THE ANTARCTIC

by

G. E. Fogg, F.R.S.

There could scarcely be a greater contrast than that between the frigid wastes of Antarctica and the fertile, hospitable, tropical island of Ceylon. This lecture may, therefore, be considered inappropriate to the occasion but, on the other hand, it must be remembered that Antarctica is Ceylon's nearest neighbour to the South and that there are good reasons why all nations should have an interest in this particular part of the world. In present circumstances the human race cannot afford to remain ignorant of such a large portion of the planet. To give a specific example, it is impossible to make long range weather forecasts without a knowledge of what is going on over the Antarctic continent. Secondly, the Antarctic is the scene of a most encouraging development in international co-operation. Under the Antarctic Treaty of 1959, the twelve nations most immediately interested have agreed to renounce all territorial claims for a period of thirty years and to set aside south of 60°S as a region for scientific research and nature conservation in which all military operations are prohibited. Under this arrangement, American and Russian, British and Argentinian, work in happy co-operation in spite of political differences.

For a botanist, Antarctica gives the opportunity not only of studying the behaviour of plants under extreme conditions but of investigation of communities consisting of only a few species, in which one might expect inter-relations to be correspondingly simple. There is also the practical point that the Southern Ocean is highly productive and a rational exploitation of this productivity to provide human food requires a knowledge of the behaviour of the primary producers, the phytoplankton.

In this lecture I propose to give a general account of the botany of Signy Island (60°43 S—45°38 W), South Orkney Islands, which I visited in the early part of 1966 under the auspices of the British Antarctic Survey. Of the six permanently manned bases maintained by the Survey that on Signy Island is the most northerly and, on account of the island's comparatively abundant vegetation and large populations of elephant seals and penguins and other sea birds, is of most interest to the biologist. The island presents a variety of terrestrial, freshwater and marine habitats within a small compass, being only five miles long. In spite of its northerly position, Signy Island is truly antarctic in character since it lies in the track of a current bringing water from the Weddell Sea to the south. More than half its area is covered by permanent snow and ice, during the winter it is frozen in and during the summer the sea surrounding it contains innumerable icebergs. Being surrounded by ocean the island has a rather uniform temperature, the monthly mean rarely falling below —11°C or rising above 1°C. The South Orkneys are one of the cloudiest regions in the world, having a cloud cover for 80 per cent of the time, and one of the windiest, with gales for 8 per cent of the time.

The low temperatures as such are not particularly inimical but when combined with wind they have a damaging effect on plant life. Thus one finds that cushions of the moss *Dricranum aciphyllum* in exposed situations are killed and blackened on the west side from whence the prevailing winds blow. The oscillation of the temperature about freezing point has indirect effects by causing instability in the substratum. As a result of alternate freezing and thawing of water-logged rock debris the finer and coarser materials become sorted out, polygons of fine material, about a yard across, demarcated by stones at their edges forming on level ground and alternating stripes of fine material and stones on slopes. The fine material is constantly disturbed in summer and does not support any macroscopic plant life whereas the coarse material is relatively stable and can support growth of mosses and lichens.

Three principal plant formations have been distinguished (Holdgate, 1964; Longton, 1967). That of rocky knolls and exposed ridges is characterized by the moss *Andreaea regularis* and the lichen *Usnea fasciata*. On maritime rocks these are replaced by the crustose lichens of the genera *Caloplaca* and *Haematomma*, which provide welcome patches of brilliant yellow and orange in the landscape. On Signy Island the principal rock is an acid schist but there are occasional outcrops of basic amphibolite and marble. The effect of the marble on the vegetation is dramatic, *Andreaea* being replaced by another moss *Grimmia antarctica* and *Usnea* by the lichen *Collema pulposum*, the transition between the two communities often taking place within a centimetre or so. A second formation is that of well-drained and comparatively sheltered situations with the

mosses *Dricranum aciphyllum* and *Polytrichum* alpestre. as dominants. This forms an attractive green sward beneath which peat may accumulate. In places this peat attains a thickness of four feet which radiocarbon dating shows to have taken about 200 years to have accumulated. The third formation is found in wet places and is characterized by various mosses of the genera *Drepenocladus*, *Acrocladium* and *Brachythecium*.

Only two flowering plants are to be found on Signy Island, a grass *Deschampsia antarctica* and *Colobanthus crassifolius*, a member of the Caryophyllaceae. Both are confined to sheltered north-facing slopes on the coast and set seed only in the more favourable summers.

For these plants and also for the mosses and lichens the micro-environment is supremely important. On dull days the temperatures of soil and vegetation are about the same as that of the air. In sunshine, however, the soil may attain temperature 10°C above that of the air, and mosses, the cushion form of which promotes a green-house effect, as much as 18°C above (Holdgate, 1964; Longton and Holdgate, 1967). It is to be suspected, although it has not yet been proved, that photosynthesis is only appreciable during these periods when the temperature of the micro-environment is high. For most of the time when the temperature is at zero or below the plants must be dormant and using scarcely any material in respiration.

My object in visiting Signy Island was to make a study of algal activity under antarctic conditions. On land the most conspicuous algae are those which form often extensive and brilliantly coloured red, green or yellow patches on snow. The species concerned are various but the most striking is *Chlamydomas nivalis*, the spores of which are deep red because of accumulation of carotenoid pigments, and the most numerous a coccoid chrysophycean which is perhaps the spore stage of a species of *Ochromonas*. The suddenness with which these patches appear on snow during a thaw suggests rapid growth under somewhat adverse conditions. To investigate this, counts of cell numbers were made in one spot over a period of a week. Numbers at the snow surface increased some twenty-fold but the total number of algal cells in the snow column increased only five-fold during this period. It therefore appears that the main cause of the increase at the surface was mechanical accumulation as the snow ablated (29 cm disappeared during the course of these observations). This conclusion was borne out by determinations of rate of photosynthesis by a radio-carbon method (Fogg, 1967) which showed only low rates, sufficient to provide for doubling of cell material in about 23 days. The snow, which receives a great deal of sea spray and rock dust, is comparatively rich in plant nutrients and it does not seem likely that zero temperatures *per se* need limit algal growth. Probably it is desiccation which is limiting. One may envisage the algal spores being carried by wind and disseminated through the settling snow, becoming active only when thaw water is available, and persisting in a dormant condition for perhaps many years in semi-permanent snow fields.

The blue-green alga *Nostoc commune* is abundant on Signy Island in moist terrestrial situations subject to the influence of the basic rocks amphibolite and marble. This is known to be a species capable of fixing the free nitrogen of the atmosphere and it was of interest to find out how actively it does this under antarctic conditions. To do this a method employing the heavy isotope of nitrogen, 15_N, was used (Fogg and Stewart, 1968). Samples of alga were placed in a flask in which the atmosphere was enriched with 15_{N_2} and after a suitable period of exposure, usually 24 hours, in the field they were preserved for analysis on return to London. From the 15_N content of the material, determined with a mass-spectrometer, the rate of nitrogen fixation could be calculated. Perceptible fixation was found even at temperatures near zero but the rate increased rapidly with rise in temperature—approximately six-fold for a 10°C rise—so again the micro-environment is of great importance. Desiccation rather than low temperature seemed to be the chief factor limiting the activity of the *Nostoc*. *Nostoc commune* is the algal partner in the lichen *Collema pulposum*, which is common on Signy Island. This lichen was also found to fix nitrogen. Another lichen *Stereocaulon* sp. has a green alga as the principal algal symbiont but sometimes also contains *Nostoc* in special wart-like structures called cephalodia. When it has cephalodia *Stereocaulon* is capable of nitrogen fixation and it was interesting to find that on Signy Island this lichen had cephalodia when growing on amphibolite but not when growing on schist. Apart from *Nostoc* in its free-living and symbiotic forms no other micro-organisms on Signy Island appear to fix nitrogen in appreciable quantities. It seems therefore that this blue-green alga plays a major part in contributing to the fertility of antarctic soils.

Turning to the freshwater, a striking feature is the paucity of the phytoplankton in spite of the fact that the concentrations of nutrients such as nitrate and phosphate are relatively high. On the other hand a thick orange-brown felt to blue-green algae, mainly *Phormidium* spp., is nearly ubiquitous on rocks and stones in streams and in the littoral regions of lakes down to 1 or 2 metres depth. Radiocarbon determinations showed this felt to be many times more active in photosynthesis than the phytoplankton in the water column above (Fogg, unpublished). Perhaps this greater activity is related to the fact that the felt is 2 or 3°C warmer than the water just above it on bright days. It seems that these benthic blue-green algae are the main primary producers in freshwater. It may be noted, however, that the species of blue-green algae concerned here are not nitrogen-fixing.

At first sight the sea seems to support no growth of seaweeds. However, one has only to see a bay full of brash ice when the sea is rough to realise that rocks are very quickly polished free of any algal growth. Here and there in crevices where the ice cannot reach the green seaweed *Monostroma* may be found together with red seaweeds such as *Leptosomia* and red encrusting forms. Otherwise the only growth to be seen is of the filamentous green alga *Chaetomorpha* which appears on rocks in the spray zone of sheltered bays. Down below the reach of the ice, however, various species of the brown seaweed genus *Desmarestia* flourish, growing up to four feet in length and, according to divers, forming quite dense beds.

In contrast to the state of affairs in freshwater, the growth of phytoplankton in antarctic seas is often dense. At the time of my visit the sea around Signy Island was turbid and brown with diatoms. It was only necessary to tow a plankton net for a minute or so in order to get a dense sample, mainly of *Thalassiosira antarctica* and *Corethron criophilum*. Radiocarbon determinations show that in terms of amount of carbon fixed per unit amount of chlorophyll per unit time the phytoplankton of antarctic seas is as active as that of temperate waters (Burkholder and Mandelli, 1965). The diatoms are grazed by zooplankton, principally the shrimp-like krill on which the whales feed, a food-chain which could scarcely be simpler.

Signy Island has large rookeries of Adélie, Chinstrap and Gentoo penguins which provide unlimited free entertainment for the botanist with time to spare from his research. This is scarcely the place for an attempt to describe their behaviour but it may be noted that little, if any, visible plant life survives the trampling within the rookery, though the ordeur which covers the ground no doubt provides for a fascinating variety of micro-organisms. The drainage from a rookery is, of course, extremely rich in plant nutrients and is often picked out by a bright green growth of the alga *Prasiola*. The tremendous impression of biological productivity given by these crowded rookeries is rather misleading since, it must be remembered, the birds obtain their food from an enormous area of sea. Holdgate (1967) has, in fact, calculated that the standing crop of penguin is only 0 · 1 mg per square metre of sea surface.

References

BURKHOLDER, P. R. and MANDELLI, E. F. (1965). Productivity of microalgae in antarctic sea ice. *Science*, **149**, 872-874.

FOGG, G. E. (1967). Observations on the snow algae of the South Orkney Islands. *Phil. Trans. Roy. Soc.* B, **252**, (777), 279-287.

FOGG, G. E. and STEWART, W. D. P. (1968). *In situ* determinations of biological nitrogen fixation in Antarctica. *Br. Antarctic Surv. Bull.*, in the press.

HOLDGATE, M. W. (1964). Terrestrial ecology in the maritime Antarctic. In *Antarctic Biology* edited by R. Carrick, M. W. Holdgate and J. Prévost; Hermann, Paris, pp. 181-194.

HOLDGATE, M. W. (1967). The antarctic ecosystem. *Phil. Trans. Roy. Soc.* B, 252 (777), 363-383.

LONGTON, R. E. (1967). Vegetation in the maritime Antarctic. *Phil. Trans. Roy. Soc.* B, **252** (777), 213-235.

LONGTON, R. E. and HOLDGATE, M. W. (1967). Temperature relationships of antarctic vegetation. *Phil. Trans. Roy. Soc.* B, **252** (777), 237-250.

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