An Address

ON

THE SCOPE AND NEEDS OF MEDICAL RESEARCH*

BY

SIR WALTER FLETCHER, K.B.E., C.B., F.R.S.
M.D., D.Sc., LL.D., F.R.C.P.

The phrase "medical research" covers an immensely wide field of scientific activity, in which workers of many different kinds are occupied. It is concerned directly and indirectly with the welfare of the bodies and minds of human beings, and if properly treated it must be a subject of the first interest to any audience. The word "medical" in this relation is likely to mislead. Strictly it refers only to the healing of disease, and it calls to mind at once a vision of doctors at the bedside and of their drugs and implements. Yet as used here it has a scope, not only in the work of original investigation, but also in preparing its results for practical application, which is indefinitely wider than that of the healing profession as such. I can give an actual definition of the real scope of medical research in formal terms. It is a formula which has been adopted by His Majesty's Government to define the field of medical research work to which an annual Parliamentary grant-in-aid is made, and it is in these terms:

"Medical research deals with the proper development and the right use of the human body in all conditions of activity and environment, as well as with its protection from disease and accident, and its repair."

Let us take each phrase of this definition in turn.

DEVELOPMENT OF THE HUMAN BODY

Here we have to consider both nature and nurture, both inheritance and nutrition. Dangerous as it is in scientific studies to separate these sharply in our minds, as is so often done, each nevertheless is served by a special scientific discipline. One is served by the science of genetics and the other by the science of nutrition. The science of genetics is still in its first infancy. By an easy effort of imagination we can form almost illimitable hopes of betterment in body and mind that fuller knowledge in this subject may hold out to the human race. Dreams of this are so attractive and may be so vivid as to tempt us to proposing short cuts to make them real. Hasty practical proposals made in the name of what is called "eugenics" are put forward. Many of these are based on obviously false assumptions, as, for instance, that particular parts of the community are not desirable breeding stock merely because at present they are inadequately fed; or, again, that the qualities which make many men rich are the qualities which we should desire to multiply in our race. Quite apart from witless social prejudices of that kind, the very machinery proposed for attaining the results desired has often no basis at all in scientific knowledge. Yet in this field some of our highest hopes for man's future must still reside. We have evidence already that the knowledge we have gained of the laws and machinery of inheritance in the lower animals holds good for man. Small beginnings are being made already by the studies of selected pedigrees, the use of probability laws, the examination of correlations between characters, either directly observable or detectable by refined methods of blood examination—all these give growing hopes of our being able to map out the distribution of factors in the human chromosomes, those minute carriers of inheritance in the parent cells. Medical know-

ledge has a leading part to play here, for the most hopeful clues now in sight depend upon a closer medical study of the inheritance of disease and abnormalities in family history. We are in practice cut off from the method of experimental mating in the study of human inheritance and must perforce use the methods of medical observation and analysis of pedigrees. The work in sight is vast and may occupy many generations. All the more important then that it should begin early. There is no short cut to the power for human welfare that we hope some day to gain by genetic knowledge. The only road to this has to be cleared up by persistent effort in this primary branch of medical research.

The other side of the study of the development of man's body, that of nurture, lies in the field of nutrition, and here there is a very different story. This study is concerned in part with the quantitative study of the energy requirements of the body and in part with the qualitative values of diet. It has only been part of exact science for the last generation or two. Our knowledge upon the qualitative side, even of the very existence of the vitamins, belongs only to the last twenty years. Yet from the knowledge so far won in this field we have already gained practical powers of high value. I will return presently to this subject of nutrition to illustrate in more detail the value and interest of this part of the medical field.

RIGHT USE OF THE BODY

Pursuing our definition we now come, after dealing with the development of the body, to the problems of its right use—its right use in all conditions of activity and environment. Here we deal with problems of personal hygiene, of sleep, of diet in relation to climate, and to bodily activity. We have to deal also with an intricate group of problems belonging to industrial life. The industrial revolution and the introduction of machinery upon a great scale brought a host of new problems under this head. Individual craftsmen throughout the ages have found for themselves their own ways of working to the best effect, and of making the compromises needed for gaining the best output with the least fatigue and damage to health. The introduction of machinery and the gathering of workers into large factories came about, as we all know, with far too much regard to the welfare of the machinery and the magnitude of its output, and with far too little regard to the machinery of the bodies of the workers. The application of physiological knowledge in this field has been lamentably slow in coming. Most of the elementary problems of maintaining efficiency in work and of the spells of rest needed for particular occupations of many kinds have been studied only within the present generation, after almost a century of waste, discomfort, and misery.

The great war brought home to us our ignorance of this branch of medical study, though no other country had greater incentive, both in duty and in profit, to lead the way in its development. When the safety of our people depended upon the fullest output of war material and the maintained efficiency of the workers, it was found that we were ignorant as a nation of some of the most elementary laws of industrial health. We had to find and apply as best we could the optimum hours of work and the best use of rest pauses for different kinds of work, ranging from heavy physical labour to light manipulative tasks involving maintained attention to rapid machine processes. When the lives of men, or indeed of armies, might depend upon the rapid use of the spade in trench warfare, it was found that nobody since Adam first used a spade had worked out the optimum rest pauses for the best performance of a gang of men digging over different periods. Medical research had also to find new safeguards for men

*Friday evening Discourse at the Royal Institution of Great Britain, May 27th, 1932.

living in submarines below the sea, mining far into the earth, or flying to great heights in the air. During and since the war a great volume of research work has been done under the Industrial Health Research Board to clear up these problems connected with the right use of the human body. They deal with hours of work (heavy or light), rest pauses, shift systems, the problems of monotony in repetitive work. They have dealt with the human factor in the causation of accidents, with problems of ventilation, of lighting and heating, with all the special problems of vocational guidance and selection, with the study of body movements, posture, and physique in particular industrial processes, as well as with the special dangers arising from poisonous materials in particular trades or occupations.

PROTECTION OF THE BODY FROM DISEASE

Here we come for the first time to what is ordinarily thought of as medical work in its narrow sense. This part of the work falls, of course, at once under two main divisions. There is the work of preventing disease, and there is the work of curing or palliating disease when already present.

We can hardly think, and have no reason to think, of disease as being caused otherwise than in one of three ways. There are diseases due to abnormalities of structure or chemical behaviour which are inherited and come from the genetic history of the individual. There are other diseases which are due to faults in the immediate environment of the body—early or late in its development—such as those, for instance, known to be the result of imperfect nutrition. Lastly, there is a great variety of disease due to the direct attack upon the body by other forms of life in the shape of parasitic enemies.

We can aim at preventing inherited disease by increasing our knowledge of genetics and by regulating human mating. It will be very long before we have knowledge enough to gain much power in this direction, and how far we can use it when gained will depend upon our political structure and social habits. Already our genetic knowledge is enough to allow us to abolish at once one type of juvenile idiocy, and greatly reduce other mental defects by regulation of marriages in the families displaying them. Many diseases of environment are under our potential control already. Diseases like scurvy, beri-beri, rickets, pellagra, are due to deficiencies of particular vitamins in the food. No doubt other abnormalities of body, including forms of mental weakness, will be found to be due to similar deficiencies, either in childhood or during embryonic life; and we know already, though not yet in enough detail, that deficiencies in diet diminish the resistance of the body to infective disease.

Lastly, we come to the great welter of disorders produced by the actual presence within the body of enemy parasites. These may be multicellular animals such as parasitic worms, unicellular forms such as the trypanosome of sleeping sickness or the plasmodium of malaria; they may be bacteria, as in the infections of typhoid fever and pneumonia, or they may be minute bodies, barely visible by ordinary microscopes, which are the so-called "viruses" causing diseases such as small-pox, measles, yellow fever, and so on. The study of these hosts and of the parasites themselves has been the work of zoologists in the field and in the laboratory, while the study of bacteria is a science by itself, with its specialized technical methods. The knowledge gained here has already given us great powers in the prevention of disease, and an important part of the medical profession is devoted to their use in administration. I would only note here how random seems to be the relation of knowledge to power within this complex field. A very little knowledge of the infective agent concerned may give almost complete

powers of prevention. We have the full power of preventing small-pox in any given man or of distemper in any given dog, yet know much less about the nature of those viruses than about that of any other of the groups I have named. In malaria, on the other hand, we have a great deal of knowledge about the life-history of the parasite and its mode of conveyance by the mosquito from man to man. We have the power of freeing any given community from the disease, but only if we have money enough to break the chain of events by getting rid of the mosquito carrier. We had this knowledge and this power a generation ago, yet there is more malaria in the world now than then, and it afflicts with its curse probably a third of the whole human race, with a death rate of two million persons a year. What is needed now is still more intensive research work that will allow us a more ingenious attack upon the parasite by methods which it may be practicable to use upon an immense scale at reasonable cost.

So much for preventive research. But protection from disease involves also its curative or palliative treatment. Here we come, and, as you will notice, for the first time, to the work of the medical profession as ordinarily understood, whether that of the physician or of the surgeon. When disease is beginning or has been established the doctor is concerned to give his help in the most effective way to the single individual before him. This offers him an intricate set of problems which make his work a special branch of applied science in which high arts of skill are based upon the knowledge available. He cannot act effectively till he has found, not only the nature of the disorder present, but its particular manifestations in that individual case. The very fact that he must avoid opening the body to look inside it has led to the development of intricate devices for observing and deducing the actual facts from the outside. I need not do more than point to the high responsibilities undertaken by the physician or surgeon to whom a human life is entrusted. At every point their knowledge and skill depend upon the results of research work of many kinds, and their powers can only advance as research work progresses.

PROTECTION FROM ACCIDENT: REPAIR

Lastly, there remains to consider, in the definition I am following, the protection of the body from accident, and its repair. The study of accidents has led to much profitable research work, of which some of the chief has been done under the Industrial Health Research Board. Accidents can be sorted out into those due to the unfitness of particular workers for given tasks, or to states of mind, or to conditions of fatigue and other states of the body, or, again, to the absence of proper protective devices and administrative rules. When their causation is accurately found, preventive work is at once rightly guided. Under this last head, too, there is the skilled work of the surgeon in repairing physical damage done to the body. But we can only point to this here as completing our rapid survey of the whole campaign in the medical field. I would, however, note how, in coming to the end of this general story, we find ourselves close to the beginning of it again. Surgery has brought us near to the study of heredity again with which we started. For uncounted centuries the surgeon has repaired so far as possible the injuries of man's body in warfare and accident, and his chief concern has always been at least to prevent death by loss of blood. There is no more ancient surgical problem than that of whether a healthy man can lend some of his blood to save the life of another. Nearly three hundred years ago Dr. Lower of Oxford showed to King Charles II and the early Royal Society that one dog's blood might be transfused into another dog to

replace its own. But it has only been in the last twenty years that we have learned why it is that, while the blood of one man given to a patient who has suffered loss by bleeding may be fatal, that of another man may have no ill effects and may restore life. Happily that knowledge came in time to save many thousands of lives in the war. Careful laboratory studies have shown that every human being belongs to one of four groups, distinguished by the different precipitating powers of their bloods, one against another. These subtle blood differences, far more subtle than any chemical analysis could detect, are of daily importance in surgery. They play a part also now in the study of human inheritance with which we began this survey.

MEDICAL RESEARCH AND THE PRIMARY SCIENCES

In this outline I have tried to show the wide sweep and scope of the group of studies properly called medical research. In spite of the widely scattered fields over which it ranges, this work is joined in an organic unity because it has ultimate reference always to the nature and the needs of the living human body. At almost every point we find interrelations between one part of the work and another, and between the various groups of workers in this extended army. While it is served, of course, by the medical sciences—physiology, pathology, bacteriology—it calls in increasing degree for intensive studies in the more primary sciences of chemistry and physics. Medicine, in fact, using the word in a wide sense, is already being served by a great army of workers, of which a large and increasing number may have no medical degrees and no direct relation to the medical profession.

The Vitamins

Let me now give one or two instances of the manner in which medical research draws upon intensive studies in the primary sciences. When the Medical Research Council began its work eighteen years ago, then, and indeed for some years later, rickets was regarded by many of the best authorities in Europe as a chronic infective disease of which the infective agent was unidentified. It was called on the Continent the "English disease" because it was first described here and because of its abundance in our smoky cities. Before the war it was estimated that in our cities at least one child in every three had obvious signs of rickets. Dr. Mellanby discovered, by laborious experimental work, that rickets was simply a deficiency disease due to the lack in the food of a particular constituent, now called vitamin D. The proper supply of this prevented rickets or rapidly cured rickets already present. Familiar now as this is even to laymen, it was greeted at first and for some years by much scepticism in many medical circles.

This discovery has led on to a remarkable series of developments. It had been found that sunshine upon the body also prevented or cured rickets, that it was the short ultra-violet rays that had this action, and that it could also be produced by artificial light. But these rays cannot penetrate more than a tiny thickness of skin, and their action must therefore be upon something at or very near the surface. Were the rays producing vitamin D from something on the skin surface? The vitamin was known to be associated with fats; it was an obvious guess that the light might produce it from the protective grease secreted upon the skin surface. A chief constituent of this is a fat called cholesterol. A loud cry from what had now become an international pack of hounds announced that this was the right line, and that irradiation of cholesterol gave vitamin D. But almost at once a more sagacious hound (if I may continue that impertinent metaphor for Dr. Rosenheim at the National

Institute for Medical Research) found with Mr. Webster that it was not cholesterol itself that gave this result, but a related substance present with it in much smaller quantities. This, after exchange of results and ideas with Professor Windaus of Göttingen, was identified as a sterol called ergosterol, previously known only as the characteristic sterol of certain fungi and of yeast. Now the problem became one for intensive study by physicists, organic chemists, and biologists working in intimate collaboration. A team of this kind, working under the general leadership of Dr. Bourdillon at the National Institute, obtained a crystalline substance of very high antirachitic activity by the physical process of distillation in a high vacuum; and another team, under Professor Windaus in Germany, obtained a very similar substance by a selective chemical reaction. Both of these, however, proved to be compounds of the vitamin with inert substances; and Dr. Callow of the Hampstead group found a method of separating the vitamin from either as a crystalline ester, from which the pure vitamin can be liberated. It proves to be itself a sterol, differing from the parent ergosterol only in a detail of the structural arrangement of its atoms, and it has been given the chemical name "calciferol." In pure form this has almost incredible biological potency. A single ounce of it would suffice to give a full daily ration for a million growing children.

It is to be noted that this devotion of physicists and chemists to a medical problem has done more than assist medical knowledge. It has yielded new additions to both physical and chemical methods. A new form of photo-electric microphotometer which multiplied fivefold the speed of observations was produced in its course, together with a new type of spectrograph. Important new contributions have been made and are still being made to our knowledge of the pure chemistry of the group of sterol compounds. In deciding between alternative possibilities of structure for these complex molecules the chemist is becoming more and more dependent on the physicist, for measurements made by the methods of x -ray analysis which science owes to Sir William Bragg. Now this progressive work is not only a clever physico-chemical exploration of academic interest. The results of this intensive laboratory work assume at once a direct bearing upon the practical needs of the community. Accurate knowledge of the vitamin allows adequate standardization of its amount in different foodstuffs in terms of a fixed standard of reference. Its artificial production, moreover, brings into action, or should bring into action, the medical administrator, who should be concerned to see that so long as social or economic factors maintain, as they do, an effective shortage of the natural sources of the vitamin among our city populations, a supply of it by means of the new methods we now have at command shall be made available for every growing child and every child-bearing mother in the country. There still remains for study the attractive physico-chemical problem of how it is exactly that this calciferol molecule exerts its special influence upon the living cells of the intestinal walls, and exactly why, without it, they cannot do their work of effecting the passage of calcium salts into the blood from the food, but not back again. Of this we now know almost nothing. Here our task is to attempt further steps towards better knowledge of the mysterious microcosm of the living cell substance.

Other fascinating vistas are in sight. Only in the last few weeks workers in the physico-chemical laboratory at Cambridge have found some evidence that the action of particular wave-lengths of light in developing vitamin D from its precursor substance may not be, as we had been thinking, an isolated phenomenon. They have obtained some indications that just as for this, so in the case of

two other vitamins—each in its own way indispensable for animal life—particular wave-lengths of light may produce the vitamin from its precursor, while other wave-lengths close to them destroy it. What we know already of the chemistry of the vitamins having these special relations to light shows that they belong to widely different types of chemical compounds. If the indications just given should be confirmed, it will seem to be, so to speak, more than a mere coincidence that in two or three different directions at least the animal cell has come to be vitally dependent upon different individual chemical substances, of which each has these remarkable photo-chemical properties. We should have to consider that we have here perhaps taken our first steps towards knowledge of a phase of evolutionary development that has not been dreamed of hitherto, a development made manifest in a highly specialized and detailed adaptation of living matter to its age-long environment of light.

The Viruses

In quite another direction the growing demands of medical research for intensive physico-chemical studies may be illustrated. Among the varieties of parasitic life that infest the animal body I mentioned the so-called viruses that cause devastating diseases in man, in animals, and in plants. The loss they cause in life and in money has a magnitude almost beyond calculation. They cause small-pox, measles, infantile paralysis, and many other diseases in man. They cause foot-and-mouth disease of cattle, swine fever, fowl-pox, and other devastating plagues in animals. They cause ruinous diseases in vegetable crops of many kinds, from potatoes here to bananas in the Tropics. They are called "viruses" at present because that commits us to no decision as to their nature. What do we know about them? In a fluid containing them they can be shown to be freely suspended and particulate bodies, for the fluid can be freed from them by rapidly spinning it in a tube so that the particles are driven to one end of it. The bacteria themselves vary widely in size as animals do. None of them can be seen without a magnifying glass, and taking the largest as enlarged to the size of a horse the smallest would then be represented by a mouse, and would be near the extreme limit of our highest powers of direct microscopical vision. The viruses are so small, however, that they pass through porcelain filters that retain all bacteria, and they are just upon or beyond the borderline of direct vision by ordinary microscopical means. Here again medical research has had to call for the intensive application of new physical methods of study. By using the shorter wave-lengths of ultra-violet light the limits of clear microscopical vision can be extended, though this involves using quartz instead of glass throughout the optical apparatus, and obtaining photographic images instead of using direct vision by the eye. It is desirable to photograph the virus bodies in their natural state undisturbed by chemical agents or by stains, which by coating their surface alter their apparent size. These methods are already being successfully applied at Hampstead by Mr. Barnard, who has been foremost in developing them. Another physical problem has been to devise suitable filters with apertures of known size and uniformity, so that the different viruses may be graded in order of magnitude, and the work separating them in the laboratory made constant and accurate. This problem has been largely solved already by Mr. Elford, also at the National Institute, who has found how to produce accurately graded and uniform filters by making collodion films under precisely controlled conditions.

Many of the known viruses have already been arranged in an order of size, and the results gained by optical and filtering methods, which are constant, agree closely where

they can be compared. They show that the viruses vary in size nearly as widely as the bacteria do. The largest are close in size to the smallest bacteria, and they descend to the virus of foot-and-mouth disease, of which the particles are little larger than the colloidal aggregates of oxyhaemoglobin in solution. There is probably not room in each particle for more than two or three hundred protein molecules. They can be present in immense number, and yet very few of them are enough to carry full potency. The fluid from a case of foot-and-mouth disease can be diluted ten million times, and yet be potent to reproduce the disease. There are many reasons for considering the viruses to be the smallest forms of life and for allowing them to be living organisms. But there are many unsolved difficulties here. The particles are far smaller than the simplest living cells which have hitherto been regarded as the smallest organizations of living matter endowed with specific character and the power of self-production. It is not certain that viruses can multiply outside a living animal or plant cell: inside it they may multiply with such rapidity as to make it tempting to think that the new particles are being formed, not by the growth and a doubling subdivision of their own substance, but directly, and by some more rapid transformation of matter, out of the substance itself of the living cell containing them. In other words, it may perhaps be as true to say that the disease causes the virus as that the virus causes the disease.

Here again we notice how great is the intellectual interest offered to the physico-chemical student, quite apart from any incentive given by the gigantic practical benefits that will certainly be the reward of successful work in this field. It may be that in the study of these minute forms we are destined to find new clues to some of the most fundamental properties of living matter and to express them in terms of physics and chemistry. It is perhaps just as likely that we may find ourselves able instead only to express physics and chemistry at this point in terms of life. It is obviously most urgently desirable that we should increase our knowledge of these tiny forms and the laws of their behaviour as rapidly and fully as possible, if only with the direct utilitarian object of protecting the life and property they attack upon such an immense scale. We have to remember, also, that beyond a doubt some forms at least of malignant disease can be propagated by minute particles of matter which have all the known characters of the viruses. That being so, it is hard not to believe that the right clue to the problem of cancer lies here, and it is in fact being devotedly pursued from that point of view.

I might give many other instances of the great refinements now attained in many directions of biological and medical work. For study of the electrical changes in rapid muscular movement the physiologist Einthoven introduced the string galvanometer, which has been so useful in the hands of Sir Thomas Lewis and others in recording and analysing the successive events in the beat of the heart, normal or disordered. This instrument has passed as a contribution from biology to the regular uses of the physical laboratory. New devices of amplification by the physicists, on the other hand, have allowed Dr. Matthews at Cambridge to follow and measure the curve of electric change due to the passage of an impulse along a single nerve fibre, while Professor E. D. Adrian there obtains an audible record by a loud-speaker of the impulse, for instance, which passes along the optic nerve of a fish when a brief shadow flits across its retina. Professor A. V. Hill follows the course of the heat changes due to the train of transient and minute chemical changes in nerve fibres that propagate the nervous impulse, and measures them with an accuracy expressed in millionths of a temperature degree. The biologist, if given two

samples of crystallized egg albumen from the eggs of a duck and hen respectively, can tell, by means of a biological test, which of them comes from which bird with great rapidity and certainty, though the detection depends on a subtle difference of molecular pattern far beyond the reach of any analysis by the chemist. Dr. Todd at Hampstead, again, has shown that the interactions of the blood between fowl and fowl can be so used as to enable the biologist, if he desires it, to identify any given hen and its family from any other hen in the world. No organic chemist has ever dreamed of performing in such subtlety as that.

THE DIVORCE BETWEEN PHYSICAL AND BIOLOGICAL SCIENCES

I hope I have said enough to show how extensive, varied, attractive, useful, and promising are the fields of medical research and how plainly they call for the application of every kind of trained ability. Medical progress, however, is greatly hampered by various circumstances that keep from its services many of the able men who are best fitted to enjoy giving their life-work to advancing it. One of the most serious of these is the unfortunate and harmful tendency, both in the schools and in the universities, to segregate physicists and chemists on the one hand from biologists on the other. At the schools this is largely the result of the scholarship system. It is found easier to cram clever boys along narrow specialist lines in physics and chemistry for scholarships at the universities, while the universities have never taken effective action so to use the scholarship system as to secure a well-balanced scientific education for scholarship candidates. As regards Oxford and Cambridge, the two wealthiest universities, the effective power in this matter lies in the hands of the individual colleges, who encourage narrow specialism in their competition for the abler boys. The result is twofold. The cleverer boys are diverted from biology, while the biologists, if any, must give up proper training in the physical subjects and themselves specialize narrowly if they are to have any chance of scholarship success. The system of university examinations at both Oxford and Cambridge encourages still further this segregation of the sciences, and at Cambridge changes in regulation during the last twenty years have made the position worse rather than better. These are not only personal views drawn from my own experience. The same opinions have been strongly expressed by Lord Chelmsford's Committee, appointed in 1930 by the Prime Minister to consider the obstacles which stand in the way of the education and supply of biologists for work in this country and over-seas.*

I must not enter further upon this educational question now. I want only to urge here that the general cause of medical research suffers greatly from the present wide and unnecessary divorce, during the earliest stages of education and onwards, between those taught on the physical side and those upon the biological side. It is wholly indefensible on any ground that schoolboys and undergraduates who have special aptitudes for physical inquiry should be confined by a faulty system to the study of non-living matter only. The problems of the living cell are at least as attractive to a keen mind as those of dead matter, and they demand perhaps greater, rather than less, manipulative and analytical skill, because of the instability of the living substance that is studied. Medicine has always been the mother of sciences, and we may remember that it was from the body of medicine—namely, from the schools of physiology and not from schools of organic chemistry—that biochemistry was born and developed as an organized university discipline. It

has been found, indeed, as the results of experience that the man trained narrowly in organic chemistry does not in general make the best biochemist. Without earlier acquaintance with the problems of living things he is less likely to break new ground than the biologist starting far behind him in purely chemical equipment. There is pressing need now for a parallel development of biophysics, not necessarily, or even desirably, as a separate discipline, but by a breaking down of the artificial educational barriers between physics and physiology, barriers so unworthy of the Greek spirit of which those very names remind us. I must not stay to speak of still another set of conditions that handicap medical progress. Of those biologists who pass on to hospital work and the study of disease as such, many who are among the fittest to make new knowledge in the sphere of clinical medicine are tempted to turn aside from the arduous path of new investigation, either because of the absorbing human interest of professional work or, again, because of their financial needs or desires.

The mastery over dead matter which physical science has given us has transformed all the conditions of human life within a century, but the conveniences offered by improved transport and improved communications have brought only superficial changes, and it is doubtful whether they have done on the whole greater service or disservice to the happiness and well-being of mankind. Our improved powers of producing wealth, as the whole world is now observing, seem already to have outrun lamentably our powers either of wisely using or even of retaining it. It is better mastery over living matter and the improvement of the bodily and mental powers of man that are needed for the real betterment and enrichment of the race. By powers of a kind that we are already in process of gaining through medical research we may hope to transform human life in ways almost unimagined now and to make a new world indeed. Without entering into dreams of the far future we know that here and now the campaign of medical research is improving our estate. Its progress and success have immediate interest for all of us and the highest claims upon the good will of all mankind. It is a campaign to diminish pain, to lessen the waste of human effort and human life, and to enrich and enlarge the powers of the human body and mind.

CANCER OF THE BREAST

X-RAY AND RADIUM TREATMENT OF OPERABLE AND BORDERLINE CASES*

BY

J. H. DOUGLAS WEBSTER, M.D., F.R.C.P.ED.
(From the Radiological Department, Middlesex Hospital)

In 1926, before the First Congress of Radiology, I presented a communication^{1,2} on fifteen cases of operable cancer of the breast treated with radium or x rays. It may be useful to summarize further work and results in this line of cancer treatment, with forty-one operable and borderline cases, and to give the results with 358 post-operative patients.

GENERAL CONSIDERATIONS

The clinical and histological types of breast cancer are so variable that under this site heading we group rather a series of different diseases than one "disease." This variety makes it very difficult to arrive at precise conclusions on the subject as a whole. In particular, the value of statistical records is always, to some degree, indefinite, as so much depends on the percentages of the different groups, clinical and histological, included in any

* Report of Committee on Education and Supply of Biologists. Stationery Office Publication, 63-75. 1932. (1s.)

* Read at the Third International Congress of Radiology, Paris, 1931.