Norman Lockyer Lecture

ON

MEDICAL RESEARCH:

THE TREE AND THE FRUIT.*

BY

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THE field of work I ask you to consider to-day is what may broadly be called medical: it is the age-long study by man of the mysteries of his own body and of its functions. If we think of the history of the mathematical, physical, and chemical sciences we see that in the successive centuries of recorded history—and here for simplicity we may take those after the Renaissance with its heritage from the Greeks—there has been a sustained progress, irregular in detail of course, but in the main a steady progress. In general, too, at each stage of advance in knowledge there has come some gain in the practical welfare or convenience of mankind. The gain has been sometimes early, sometimes late, but there has been no general and obvious dislocation in time between the stages of growth in the stem of knowledge and the harvest of its fruit as measured in new practical powers. This is manifest even if we exclude the most modern developments and consider only the three centuries from, say, the accession of Henry VIII to that of Queen Victoria, and consider the growth during that period in the powers of man to control his physical environment. In the practical arts depending on the development of these physical sciences, in all the arts of engineering and of manufacture, the world in that time had become almost transformed and was on the verge of an even more rapid progress. A continuous development of science and of its dependent arts had proceeded side by side, never far out of step at any time.

How widely different is the story of the medical sciences and of their fruits in practice! Like the physical sciences, the biological and medical sciences descend to us almost wholly from the Greeks, while our medical arts are almost purely Greek in their origin and in their ideals. After the renewal of the Greek tradition at the Renaissance we may take as a fixed point that of the publication by Vesalius of his *Anatomy of the Human Body* in the decade before 1550. Vesalius (of whom it is far too often forgotten that by his mother he was half an Englishman) finally broke the long tradition of appeal to the written word and opened again an era of direct observation and of the fearless record of natural facts. From his time through three and a half centuries there came an ever-widening knowledge of the structure of the animal body, accelerated and deepened by the invention of the microscope just over a century after his time. Modern inquiry into the functions of the body has followed the path opened in the early seventeenth century by Harvey, who in his demonstration of the circulation of the blood showed a perfect combination of the methods of observation with those of experiment. Throughout the seventeenth and eighteenth centuries the floods of new light coming from the long line of anatomists and physiologists that followed Vesalius and Harvey were illuminating the darkness in which physicians and surgeons seeking fresh practical powers had hitherto worked. Yet in those three centuries we cannot fail to be struck by the relative absence of medical progress having any practical significance in aid of the suffering of mankind. We may compare again the time of Henry VIII with that of the accession of Victoria, a comparison that shows such immense advance made in the mechanical arts.

Over the same period, what was the progress made in the medical arts, side by side with the steady gains in

knowledge of anatomy, of physiology, and even of chemistry? The art of the surgeon had been aided by more accurate anatomical knowledge and by instruments more delicately made by new manufacturing processes, but that art was still little more than a craft of amputation; the theatre remained a mediæval shambles of blood and pain, and the succeeding putrefaction was accepted as in its nature inevitable and irresistible. In medicine the new physiology that had developed after Harvey had given to the physician new meaning and precision to his work. At his best he followed still, as the Victorian era began, the high moral ideals and sensible practical methods of the Hippocratic school. In so far as he had discarded traditional mediæval rubbish he was only returning to Hippocrates; but in effective power to cure or control disease hardly any progress could be claimed for the profession. Descriptions of diseases had been improved, and the arts of diagnosis. While some fashions of practice gave more palliative comfort to the patient, other fashions gave less. In sum, the advance made had been so slight that it may be expressed by what that learned medical historian Dr. Charles Singer wrote in 1921 of the Hippocratic physician: "His general armoury may be described as resembling that of the modern physician of about two generations ago." Yet the interval between the one and the other stretches over twenty-three centuries, of which the last three had been a period of scientific progress going far beyond the end-points of Greek knowledge, and included not only Harvey's transforming work, but also the introduction and use of the microscope.

No doubt you will already have thought of an event which appears to stand in obvious contradiction to the argument I have been developing—I mean the discovery of vaccination for small-pox, made by Dr. Jenner just as the nineteenth century began. But what were the circumstances of his triumphant achievement? Jenner was struck by the fact that small-pox was never suffered twice by the same person, and he was led by simple reflection and by a tireless but empirical ingenuity amounting to genius, to introduce protective vaccination, inflicting cow-pox for protective purposes as a substitute for small-pox. He knew nothing of the agents he was dealing with or their mode of action, and we know almost nothing of them to this day. To my mind this discovery provides one of the curious paradoxes of medical history. It serves to illustrate again the striking divorce between progress in biological science and progress in the medical arts to which I have been pointing. It gives the converse of what we have just been considering. Here was no new step in science, or the result of any. Jenner tried, as we may say, an ingenious practical dodge; it was not more than that, though it brought the release of whole nations from a welter of pain, and from horrid risks of lifelong disfigurement or of untimely death.

How are we to explain the remarkable relative impotence of the medical profession at the point of time I have arbitrarily chosen—the accession of Victoria? As we have noticed, the basal sciences of anatomy and physiology had made great strides, but the arts of the physician and surgeon remained much as they had been for ever twenty centuries before. It is true, of course, that at that time the state of the biological sciences was far behind that of the physical sciences, having regard to the special characters of living matter and the special difficulties of its study. Organic chemistry was hardly born, bacteriology barely dreamed of, and the knowledge of cell life hardly begun. But while recognizing that, it seems plain that a great part of the sterility of practical medicine lay actually in the high development and the attractiveness of the practitioner's work as an art. His work is affected by personal and emotional relationships unknown to the practitioner in engineering and kindred arts. An essential part of the Hippocratic tradition, and indeed an obligation that every honourable practitioner must recognize, is that the physician in serving a patient must concentrate all his attention and effort upon the individual necessities of that particular case, upon its right diagnosis and due treatment; it is his duty to lay aside all speculative consideration irrelevant to the individual set of complexities presented to his judgement. The sterility arising from the inevitable failure

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of the practitioner studying individual patients to make scientific progress among the complexities of living matter was clearly seen by Francis Bacon. In the dawn of the new physiology after Harvey, active practitioners like Harvey himself, and others like Glisson, Lower, Willis, Mayow, and Sydenham, in that galaxy adorning the seventeenth century, threw themselves eagerly into the work either of direct experimental inquiry or of the classification and study of collected medical observations. But after that bright age the profession in the main held aloof from experiment, and concentrated their efforts upon giving the most punctilious, and at each moment of time the best available, diagnosis and treatment of individuals. The work of individual diagnosis, based on more accurate nosology and on improving arts of observation, became more elevated as an art. But the art remained at best only the skilful attendance upon the natural curative forces of nature. Throughout the many centuries of its development it did not bring any essentially new powers of dominion over the natural processes of disease and of recovery.

Our pause at the beginning of the Victorian Age was convenient because that point marks the opening of a new epoch for the biological sciences. The first artificial synthesis had just been made of a carbon compound, urea, naturally arising in the body, and the new science of organic chemistry had just come to birth. Improvements in the methods of work with the microscope had revealed the structure of the animal cell, and it became possible to express the phenomena of disease as disorders of cell life and not as indefinite "humours" or influences mysteriously affecting the several parts of the body. As the Victorian Age advanced the microscope gave the key to the nature and life-histories of the innumerable internal parasites of man, and revealed the impossibilities of man sharing with other animals or with insects an alternate interchange of parasitic agents of disease. The work of Pasteur and of Koch founded the new science of bacteriology and opened the first chapter in our direct knowledge of the swarming world of minute potential enemies or friends of man and in our powers of dominion over it.

The last four or five decades have seen a development of knowledge in the sciences contributing to medicine that has no parallel in previous history. The increase of new knowledge here and in other countries has come, indeed, so tumultuously and so rapidly as to allow no proper time for the necessary adjustments of the machinery of education, or of the traditional systems of medical education. The universities have been embarrassed to make proper provision for this rapidly expanding scientific activity and for the new branches of work that have made claims to constitute new sciences. Problems of the gravest kind in the field of medical education have come upon us so swiftly that reflection and adjustment have not been able to keep pace with them. I can illustrate this kind of difficulty best by saying that the medical student of to-day, coming to his work at the same age and giving to it the same necessary minimum of five years as his predecessor of 1900, is presented with a body of facts two or three times as great and in some subjects five times as great as that with which the former student of the same age and ability had to deal. To meet this state of affairs, full of danger as it is to the real educational welfare of the student to-day, radical changes in method and scope are obviously required and are overdue.

While this period of rapid progress is rapidly changing the traditions and methods of the medical profession, the improvements in general scientific education which have slowly occurred in the last generation are allowing the layman to take more and more an informed interest in his own relations and responsibilities to the scientific workers and to the medical practitioners and officers in whose work and welfare he is so vitally concerned.

Most laymen have observed already the great changes that the rapid growth of biological science has brought about in the conditions of the practice of the physician and of the surgeon. Easily within the memory of men now living surgery has passed from the limitations and horrors of all its previous ages and has become a merciful and delicate art. It has advanced by steady degrees until

almost the whole territory of the human body has fallen within its easy mastery. This has been due to the insight, experimental patience, and humanitarian fervour of Lister, whose work is familiar to all. In this past generation, moreover, the surgeon's new powers have brought him new means of observation of the living body. Many have done pioneer work in advancing their craft, of whom Horsley, in this country, must stand as a chief example. These have used the fresh insight they have gained in their professional work to advance scientific knowledge, and have made experimental studies in laborious days systematically dedicated out of the routine and out of the remuneration of professional work. As to the art of surgery itself, it is difficult to imagine that it has any further advance to make of a major kind. Indeed, Lord Moynihan has confessed that in his view the art has almost reached its ultimate limits, undeterred by the fact that the same opinion was held by leading surgeons immediately before the advent of Lister. All present probability is on its side, however. We must believe that we have seen already the zenith of surgery in the world's history, except in so far as it must remain to deal with wounds and accidental injuries. Every step forward in medical science is a step towards the abolition of surgery.

The physician during the same period of rapid scientific progress offers a picture strikingly different from that of his fellow worker in surgery. Science by the hand of Lister gave the surgeon his new fields of work, but it was the surgeon himself who then developed his craft and pushed forward its applications. His new work gave him new knowledge and improved his own powers of diagnosis, and made him increasingly a physician himself, or the more intimate partner of the physician. But the physician's modern progress has not in the same sense depended on himself. Advances in physiology and the new sciences of biochemistry and bacteriology brought new life, of course, to every part of the physician's work and brought him also many new fields of application. But throughout this modern period the initiative as regards new methods and new remedies has steadily passed away from the physician himself to the scientific worker in the experimental laboratory.

We saw that up to quite modern days the physician followed the strict Hippocratic tradition of concentrating his powers upon the welfare of the individual patient. He relied greatly, if not chiefly, upon rest in bed and upon the *vis medicatrix naturae*. He gave drugs for the palliation of symptoms, but had few, if any, weapons for attempting the specific cure of disease. His art, an art highly developed and refined, almost expended itself upon diagnosing accurately the exact process and the end-result of the disease. I am not forgetting, of course, the exercise of his skilled functions in the right management of the patient's state of mind and in giving sympathetic and practical help to his friends—functions which in the physician's art at its best have always invested his office with a high nobility. But through the past generation it has been his medical and non-medical colleagues in the scientific laboratory who have been putting into the physician's hands new weapons of precision, in the forging of which he has played little part himself and the mode of action of which he has to take largely upon trust.

The new sciences of organic chemistry and pharmacology have been yielding many new drugs artificially built up in the laboratory, that have specific and measurable actions upon particular microbes causing disease. Of these, salvarsan may stand as a type. Chemistry and pharmacology together have also given a new meaning to some of the oldest drugs that, after immemorial use by native tribes, have been prescribed by physicians for many generations. Besides the specific remedies such as ipecacuanha and cinchona now provided as weapons of more precision for the physician, another important group of remedies has come into his hands. These are the so-called hormones—substances naturally produced within the body for the chemical control of particular functions. Knowledge of these is the result of the steady development during a whole generation of this branch of physiology, and in this British workers have played an active and most distinguished part.

I must not stay to dwell upon these and the innumerable other resources that have lately been added to the physician's armament against disease, among which I can do no more than mention the large group, including the vaccines and immune serums and antitoxins, coming to him from the work of the bacteriologist and immunologist. I would note in passing, however, that most of these new biological substances used by the physician are incapable of having their effective strength measured by any simple means of weighing or chemical analysis. The indirect methods necessary for measuring and standardizing them have been worked out, or are still being worked out, in what constitutes almost a special branch of research work. Without this the physician would be quite incapable of knowing either what dose to give or whether a given quantity purchased contains any given effective strength, when the life of the patient might be gravely endangered by any excess or deficiency. A piece of legislation for which scientific men have long been pressing gave us in 1925 the Therapeutic Substances Act, which now makes it possible for the physician and his patient alike to have a guarantee that what is sold to him is what it professes to be, both in potency and in purity, and the directions in which this guarantee can be given are being steadily extended as scientific work in the laboratory is enlarging the present possibilities. I must also avoid giving more than a passing reference here to those interesting and varied constituents of food called vitamins, upon the due supply of which this or that function of life is found to be dependent. Yet no chapter of biological science has greater theoretic interest than that which their discovery has opened, and no great step forward in knowledge seems likely to have a more profound influence upon the future of the medical profession and upon our powers of maintaining health and right living.

It amounts to a truism to say that progress in the practical arts of medicine in any of its branches, whether preventive or curative, only comes from the growth of accurate knowledge as it accumulates in the laboratories and studies of the various sciences. We find it a law of our state of being that where only observation can be made the growth of knowledge creeps; where experiment can be made knowledge leaps forward. The observation and description of diseases by physicians over many centuries have led, as we have seen, to almost imperceptible advance. The experimental method, only fully and widely applied in the last generation or two, has given more progress in each decade than all recorded history before. The lay public, however, who hold so vital a stake in this progress of natural knowledge, hear from time to time of a new medical discovery, but in general only after it has been handed over, so to speak, from the scientific workers to the service of practical medicine. The public see it first in the hands of the physician or the medical officer. They see little indeed of the workers from whose labours the new advance has come, or of the patient, skilled, and many-sided efforts that have contributed to its coming. They see and hear of the fruit when it has been plucked for their needs, but they see and know little enough of the tree from which it has been gathered. My chief object to-day is to show if I can how important it is that the educated public should understand the needs of this tree and the desirability of attending to its due cultivation.

We may know in the first place that as the body of accurate knowledge grows, like a tree with its stem and branches, the fruit in practical usefulness will certainly come in due course. All experience shows that. But we know also that the fruit can be expected at no regular season, and the time of its coming can hardly ever be foretold. Blossom and fruit may come upon some newborn twig, while well-established and healthy branches are slow in coming to any practical harvest.

Appetite grows by tasting, and the public, having received some of the benefits from the fruit of this tree, call loudly for more, and forget that none can be expected except by patient attention to the fruit-bearing branches and the patient cultivation of the main stems that bear them. In their bitter need suffering men and women will call out for the rapid production of some particular benefits. They will name their fruit and offer money to

obtain it, though they may have long neglected the needs of the tree that alone can produce it, and while they ignore the plain fact that it can hardly ever be foretold from what part of the tree some particular fruit may come. I will drop this parable for a moment and use direct language in illustration. The ghastly menace of cancer that faces almost all of us is becoming more vividly realized since the stupid taboos that have handicapped its discussion have been dropped and since better information has been given of the amount of risk and of what it entails. Eager demand is made that the cause of cancer should be ascertained and a cure provided. The demand is natural, but in making it we must realize that new knowledge about cancer will only come and can only come as an incident springing from developments and use of our knowledge of processes deeply seated and at present hidden within the life of the animal cell. That deeper knowledge is growing, and it is growing in several directions, but no honest man would ever guess along which of them and at what stage the long-desired fruit will be gathered. It may come, as other great boons have come, by some lucky quick development, or it may be long deferred and come at last as the end-point of some extended line of work. No course of action can be supported by the wisdom of experience except that of giving every aid to the full and free development of the sciences which are here concerned. To force any undue concentration upon the immediate practical result must be unwise. Abundant experience has shown it to be sterile.

Another mistake into which the community are not seldom betrayed is to give disproportionate attention to some fruit gathered in a new practical discovery or device. It may be so obviously and highly desirable a boon that when it comes it may excite undue attention and indirectly lead to the fundamental error of forgetting the tree from which it had been gathered. Every personal honour may be rightly paid to him who plucks the ripe fruit from the branch, but it is neither to the honour of the public, nor in the long run, as it can be shown, to their advantage, that this should eclipse the credit due to those whose toil had produced that fruit-bearing branch of knowledge.

Mankind naturally will always be eager for practical progress in medical work. As we have just said, every layman now knows something of the many recent triumphs in medical science, but he knows also that these are isolated and incomplete. He sees clearly that, rapid as our progress has been within a period of years, amazingly short when compared with the preceding centuries, we are not yet in sight of anything like a victory over disease all along the line. To rest satisfied with our present achievements would indeed be a counsel of despair, and nothing could be more foolish or inhuman. Though our failures and deficiencies may be great, yet the successes already gained in the last few years, which are but as a brief moment in the history of man, should give us boundless confidence. Only the growth of scientific knowledge can bring success, and every victory must wait, as we know, upon the efforts of the unseen army of scientific workers. Practical statesmanship will turn at once to consider how that army can be aided and how it can be augmented. Three centuries ago Bacon wrote:

"If you will have a Tree bear more fruit than it has used to do, it is not anything that you can do to the boughs, but it is the stirring of the earth and putting new mould about the roots, that must work it."

To turn this advice of his into practical effort to-day we must consider in respect of our scientific army the primary questions of recruitment, of pay, and of status.

As to recruitment, it can only be in the universities that the ablest young brains will be caught for the service. While it is true, indeed because it is true, that, as Burke said, "the State is a partnership in all science, a partnership in all art, a partnership in every virtue and in all perfection," that Government will always be wise that makes the universities strong and leaves them free. Much might be said of the modes of recruitment within the universities and of various influences that may impede it. I can only assert now that in the work of medical research there is a real shortage of able recruits. The public some-

times clamour for the removal of some dreadful evil, and expect a discovery to be produced if enough money is subscribed. They do not realize that the number of effective workers can only be increased by slow processes of recruitment and training.

If the service of research workers is to be recruited and maintained, questions of pay and status must have paramount importance. So lately as until just before the war it was the almost universal rule in this country that nobody should be paid for doing research work as such. Unless a man had private means he could only keep himself at research work by being paid to do something else, which very commonly conflicted with it. Much of it has always been done, of course, by university professors and other teachers heavily burdened with routine official duties. Salaries in academic life are in general indefensibly low. Even now professors, who may be most eminent men of world-wide reputations, are fortunate if they receive £1,200 a year, which was the low normal standard fixed by the recent Royal Commission for Oxford and Cambridge, and only a few with special administrative responsibilities receive £1,500. These are salaries which men reaching eminent success in any other walk of life would regard as an offence, and even in the academic world the headmaster of a great public school would think of them derisively. In the junior university posts the salaries are relatively even lower. A man of distinguished ability, whether in teaching or research, may count himself lucky if after an expensive training and years of toil he earns £500 a year before he reaches 30. It is true that since the war the nation has greatly increased the resources of the universities by direct grants made through the University Grants Committee, and indirectly by the funds made available for the several departments responsible for promoting research work in the three fields of agriculture, medicine, and industry respectively. Those bodies have done much to remove the discredit of starvation wages for scientific men, but it is obvious that they cannot do more than lead the way in the right direction, and not so rapidly as to bring dislocation to the university systems.

Luckily the work of scientific research is highly attractive to most eager minds, whether for its intellectual interest or for its promise of usefulness to mankind, or both, and men will always be drawn to it without the lure of high salaries. In my daily work I am continually finding men or women giving service of first-rate value to science and to the nation, yet receiving for their willing toil only a small fraction of what they might have earned in closely allied professional work or in other walks of life. I am very often reminded of what was heard during the war from a wounded man in a hospital in France. A gallant fellow, well over 50, and the chauffeur of a millionaire, was asked why he had left a secure and useful job at home to fight; he smiled through his bandages and said modestly, "I suppose my curiosity got the better of my intelligence." Very many research workers I know are entitled to make the same kind of whimsical but heroic explanation of their motives. Of these not a few face grave danger to their own lives in their laboratory work. In the long fight against yellow fever alone the names of three young English workers, Myers, Stokes, and Young, appear upon the International Roll of Honour of those who have given their lives in that campaign, in which the final victory now seems so near.

Not only fairness, but enlightened self-interest, should provoke any nation to bring the pay of competent research workers to such a level that they may hope in middle life at least to be able to bring an education as good as their own within the reach of their children. Until that is done we are in practice ensuring the sterility of those who, almost by definition, must be counted as among the most desirable begetters of our future stock.

Considerations of all these kinds have special weight in the interests of medical research in particular. Many workers in this field have a medical training, and they are exposed from the beginning to the rival and powerful attractions of medical practice. This is perfectly understandable upon any ground. The medical profession, as Sir James Paget said, "offers the most complete and constant union of those three qualities which have the

greatest charm for pure and active minds—novelty, utility, and charity." The attraction towards this noble profession is strong enough without reinforcement by economic and social attractions. Consider how great these must be. Men who are making any progress at all in research work have, by that definition, exceptional ability. Given even a moderate share of character and personality—and many of them have these in rich measure—they could always, by entering practice, double or treble their income, and with good fortune become rich men. Consider the social attractions. By passing into practice they escape the uncertainties and often crushing disappointments of the research life for the immediate certainty of giving help direct to their fellow creatures. They give up the obscurity of the laboratory, with its long hours of unseen toil, for a life of active and conspicuous usefulness among their fellows, and as success comes to them this intercourse brings them friendships among powerful and interesting men and women whom they would never otherwise have met, together with every amenity and comfort of modern life and modern sport. It is at present likely also to increase greatly the chances of advance in public recognition and social rank. By passing into professional practice a man may give faithful and useful service to the community, but his service in research is inevitably, and except in the rarest instances, totally and finally abandoned.

These considerations are too seldom expressed and weighed. The problems suggested are probably soluble only in part during our own age, with its social organization and its standards of value and of reward; but it is practicable at least to set out steadily along the paths already opened towards relieving scientific workers from financial anxiety and towards a better appreciation of their primary value to the State.

I have tried to bring to your minds to-day a conception of the organic growth, with all its ramifications, of a tree of knowledge making the whole body of known biological truth. I have spoken of the largely unseen body of men upon whose efforts this growth depends. Mankind, helpless otherwise, has gained new powers over suffering and fuller life already from the fruits of this growing knowledge, and it waits anxiously for new powers again that may add to those boons. If we look at the brief period in which our present knowledge has grown, a period making an almost imperceptible point of time in the immense ages still stretching before mankind on the globe, we are encouraged to look confidently forward to a long vista of scientific progress that will bring powers of control over the processes of life of which we can hardly at present conceive. These will bring with them resultant changes in human society in a thousand ways now almost unimaginable. The value to the community of a body of men and women working to gain that new knowledge upon which the possibilities of greater happiness and works of greater mercy will spring is great. But it is not to be measured in terms only of those material fruits. The moral health of the whole community must gain from the presence within it of a band of workers whose business it is to seek out the truth and whose work from its nature can only go forward in strict obedience to the truth and by means of its pursuit and expression without fear and without favour. As the Dean of St. Paul's has lately said, in the scientific life "a keen mountain air" is breathed, and something of the tonic air of this must always serve to brace and to elevate the general community.

The true worker in natural science can owe no allegiance to any tradition however venerable, or to any master however beloved. In his work he can only serve and express the truth, and for him the truth is that which can be tested by the touchstone of an appeal to nature. He must forswear any selfish or sectional allegiance: he is "*nullius in verba*" and that phrase of Horace has become in shortened form the familiar and honourable motto of the Royal Society. If we attempt to measure the value of the scientific life within the community we must put in the first place not the material fruits that spring from it, but the service it does to our reverence for truth and for the beauty it portrays.