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Some Aims and Aspirations
of Science

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FROM A MODERN
UNIVERSITY

SOME AIMS AND ASPIRATIONS

OF SCIENCE

BY

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P R E F A C E

THE essays included in this volume are a selection of occasional addresses which have been given during the last fifteen years on some of the topics that confront a man of science engaged in a modern university. They may be of interest in showing one aspect of the educational campaign that is being carried on in these newer centres of learning. Like any collection of addresses, this one may weary by its repetitions and reiterations; but on consideration it seemed better, and it has certainly been easier, to reprint the essays individually without alteration, than to attempt to combine them into a more systematic treatise on science and education. The concern of the author, it will be seen, has been to raise his voice equally against pedantry and Philistinism, the Scylla and Charybdis through which our Universities need to-day such careful steering.

A. S.

LEEDS, *Jan.* 1921.

C O N T E N T S

	PAGE
1. THE MODERN UNIVERSITY MOVEMENT	9
2. PROFESSORS AND PRACTICAL MEN	25
3. THE RELATION OF UNIVERSITIES TO TECHNICAL AND PROFESSIONAL EDUCATION	40
4. SCIENCE AND THE PRESS	52
5. THE UNIVERSITY AND WOMEN'S WORK	66
6. THE PLACE OF SCIENCE IN INDIAN NATIONAL LIFE	79
7. GERMAN SCIENCE	95

*The Modern University Movement*¹

IT has been said that the future historians of England will record the foundation of its five new universities as the most noteworthy incident that has marked the opening of the twentieth century. The movement has been spoken of, in a picturesque way, as the Northern Renaissance. I think that we who have lived through this period may be inclined rather to date the genesis of the universities in the nineteenth century, and to reckon it among the great movements for emancipation of people and liberalization of institutions, which will make that century and the Victorian age for ever memorable.

The university colleges, out of which these new universities have grown, seem to me to owe their origin not to anything that can be properly called a Renaissance. University College, London, and the Owens College, Manchester, were the first, and I think there is the clearest evidence that their success was determined, at the outset, by two factors; firstly, by their providing higher education for those who were unable to subscribe to the religious tests imposed by Oxford and Cambridge, and secondly, by the liberal recognition which they gave to natural science. At a later stage, they became distinguished as the academic resorts of the poor in purse, and as the nurseries of applied science.

What has happened at the beginning of the twentieth century, has been the conferment on single colleges of the power to grant those greatly overesteemed certificates of knowledge known as degrees, which previously had to be

¹ An address to the Leeds Arts Club, delivered November 10, 1906.

acquired from some more or less independent examining board.¹ It is true that this last step is a very imposing one; it has been taken with difficulty, it has aroused much interest, and its consequences are considerable. But it has not altered in any material way the aim or policy of the institutions concerned, which, in some cases, would have become independent universities much earlier, if certain predilections or prejudices had not been insuperable. Their right and their need to call themselves universities were challenged in high places and in low.

This will lead us to ask the inevitable question—what is a university? The question may be answered in two ways: either by rhetoric, or by matter-of-fact illustration. For the present I will keep to matter of fact; later I may use some rhetoric, but it shall be borrowed, and from a good source. There are Oxford and Cambridge universities, Glasgow and Edinburgh, Paris and Berlin, Harvard and Jonas G. Clark, presenting among themselves many important and striking differences. But the English idea of a university has been based on Oxford and Cambridge. It is hardly possible to exaggerate the influence which this prepossession has had, and still has, on the attitude of Englishmen towards all university questions.

To an Englishman, a university is something very old, very venerable, very picturesque, very large, very select, very detached, and, of course, very learned. Those who have had to fight the cause of the new universities have found themselves between the upper and nether millstones which bound this conception of a university. The highly educated Englishman, who as a rule has been at either Oxford or Cambridge,

¹ The Victoria University was founded in 1880 and its degrees were available for students of Owens College, from that date; for students of University College, Liverpool, after 1884; and for students of the Yorkshire College, Leeds, after 1887.

is the upper millstone. He has been aghast at our newness, our smallness, our poorness in this world's goods, our inconspicuousness, our ugly mundane surroundings, our incompleteness in range of studies, our poverty in the number of learned men, our poverty in halls of residence, our strange new studies about leather, dyeing, and brewing. The nether millstone has been the man who has not been at Oxford or Cambridge, who does not believe in them, who associates them with pedantry, ecclesiasticism, class education, idleness cultured or uncultured, and who has doubts whether even knowledge of leather, dyeing, and brewing, when acquired in a university, is likely to be of much value in the work-a-day world.

Well, I understand both points of view, and I sympathize heartily with both. It seems to me the most natural thing in this world that we should have these difficulties to encounter. But happily we have had in our founders a body of men whom the public could trust, men who on the one hand occupied in the world of business a position which was a guarantee of their zeal and sagacity in practical affairs, and who on the other hand were so obviously imbued with high ideals of life, that they could never be suspected of a desire to look upon higher education merely as an instrument for the service of Mammon.

Here, in my opinion, do we find the main current of the new university movement. It is characterized most of all by this, that it embodies an attempt to infuse intellectual life into the daily work of the modern world; not merely to superadd to work the means for a cultivated leisure, but to endow work itself with something that will enter into its very life-blood.

The nineteenth century embraced a period of unparalleled industrial development, and more remarkable to us than the increase in volume of industry is the alteration in its character. The arts of industry and commerce were transformed into branches of applied science. Do not suppose that I mean to

imply that they are no longer arts, or that to call a man an artist in his work is not still the highest term of praise. All I say is, that the arts of industry and commerce have now a recognizable scientific basis, and that no man can now be held to be fully equipped for their pursuit unless he is familiar with the sciences that underly and suffuse them.

We may look upon this from a utilitarian standpoint ; we may instance the great fortunes that have been made by men who have known how to turn science to practical account ; we may point to industries which have prospered and industries which have languished, in proportion to the attention which has been given to their scientific basis. But we may look upon it also in another way. If we believe in the dignity of labour, if we wish to see in it something more than the earning of a wage or the accumulation of a fortune, we shall seek to ennoble it in every way we can, to shed upon it all the light that science and learning can afford, and to ensure that it shall be elevated by the delight which comes from the exercise of a trained understanding.

Many things have contributed to the establishment of the new universities. The most important that I have not yet mentioned has been the great growth of popular education, the construction of that much talked of ladder which begins in the elementary school. The towns have been producing an ever-increasing number of young people who have had the capacity, the training, and the inclination for higher study, and who, from lack of means, have required that it should be supplied at their door. The great demand for school teachers has added incidentally to the urgency of this need.

It is, I think, easy to see how we have come into being. The causes already named ; the existence of religious tests at the old universities ; the tardy cultivation of natural science there ; the great expansion of industries and their interpenetration with science ; the growth of popular education

—these are reasons enough, without supposing that there has been a re-awakening of intellectual zeal or a resumption of ancient studies such as characterized the Renaissance. Here, at least, we are ; let us consider what we are and what we are likely to become.

The new universities seem, indeed, very different from Oxford and Cambridge, but I believe the difference is by no means so great as many people suppose. The University of Leeds or of Liverpool presents a very different picture from that of Oxford or Cambridge, but the difference is more in the frame than in the picture. Oxford or Cambridge is in reality, as in the popular imagination, a vast university, with something of a town in its neighbourhood ; Leeds or Liverpool is a vast town, with something of a university in its neighbourhood. In one case it is nearly all canvas, and in the other nearly all frame. But it must be remembered that at one time Oxford, at least, was no less important an English city than Liverpool now is, and that in those days the intrusion of a university was looked upon by the citizens not only with coldness, but with violent disfavour.

I have no wish to make little of the difference between the old universities and the new, but it is not uninteresting to contemplate either the past or the future as well as the present. As to the future, there are two possibilities to consider. Suppose that something should occur to make Oxford and Cambridge great centres of industry, to pollute their air, foul their rivers, blight their trees and lawns, cover their buildings with a film of tar and fill their streets with crowds of artisans ! They would become much like ourselves. I do not think this likely. But there is the other possibility. Suppose that something should occur to transform the conditions of industry, that the extended use of gaseous fuel and electricity should abolish our pall of smoke, that goodwill, which is wanting, combined with good knowledge, which is

not wanting, should cleanse our rivers, and that our religious zeal should manifest itself not so much in an anxiety as to what creeds our children are taught at school, but in an irresistible endeavour to secure that these same children shall be reared in homes and surroundings that provide at least the common decencies, the cheaper privileges, and the simpler joys of civilized life! Then, I think, we should be surprised to find how much we had grown to resemble a university town.

This is a possibility that I do not think unlikely to be realized. I think that it is not even remote, and thinking so, the fundamental question about our new universities becomes to me this—is it well, in any case, that a university should lie near the heart of industry, or should it be remote, secluded, rural, far from the madding crowd?

There is much to be said on both sides, and I am not insensible to the eloquence with which pleas have been uttered for the almost monastic seclusion of a university; but so long as great cities exist, I am wholly in favour of our universities being by their side. To state the reason compels me again to speak of Oxford and Cambridge, and I should like to take the occasion to say how far it is from my desire to speak of those great institutions with any lack of respect. It would ill become me, for in the first place I was educated at neither, and in the second I know how indebted the new universities are to the Oxford and Cambridge men who have brought to them aid and enlightenment that have guarded and guided their infancy.

My belief in the wisdom of establishing universities in the centres of industry is based on both experience and anticipation. Experience has led me to think that English education and English life have suffered to an almost incalculable extent by the isolation of our ancient universities. The want of geographical contact between the greatest seats of learning and the busy

hives of industry seems to me to have been attended by mutual disadvantages, and to have placed in actual opposition two spheres of human activity that in a well-regulated world should be coincident. I do not think I over-state the case. Broadly speaking, the old universities have been the training ground of statesmen, lawyers, parsons, schoolmasters, and doctors—in a word, of the learned professions—whilst they have been to an almost negligible extent the training ground of those who immediately direct and control the world of commerce and industry. It cannot be surprising then that there has come about something like an antagonism between the conventional university man and the conventional man of business, or if not an antagonism, then a marked want of sympathy. This is not to be found to anything like the same degree in Scotland or in Germany, where the universities are among the people. I know it has been maintained that a university cannot intellectualize its neighbourhood. Newman uses these very words. They may be true of a rural university, but surely they are not true of one placed in a city, and especially of one in which the studies bear closely on the surrounding industries.

One great misfortune of an isolated university is that its government falls into the hands of a purely academic group of men; there is no chance of that association of men of thought with men of action which produces a mutual sympathy and understanding, and which checks the excesses to which either class is prone. There can be no doubt that among a great many men, not mere scoffers, but earnest, thoughtful men, there has been a belief that to send a son to the university was not only of no direct intellectual advantage for the purposes of what is called business, but that a young man might thereby acquire a positive distaste for business, and perhaps be diverted altogether from it. On the other hand it can hardly be denied that there has been a feeling of repug-

nance in the academic world towards those studies which are most closely related to the practical arts.

Looking at universities merely as seats of learning, I can see nothing but mutual advantage in their contact with great towns, and I look confidently to this close association for the destruction of a barrier that has been both artificial and mischievous.¹

It may be thought, perhaps, that I have insisted too much on the part which science has played, and is to play in our new universities. I cannot deny that, in my opinion, science has been their mainstay and that it will continue to be so for some time to come. Nor do I deny that the sympathy and support we have received have been based to a large extent on the just belief that our work may minister to the success of industry. But I am happy to say, and I say it most emphatically, that if the sole purpose of our new universities were to make industry and commerce more effective instruments of either personal or national wealth, you might indeed find men to staff them, but you would not find men who were worthy of their hire, and you would have nothing that had a just claim to the title of a university. No, the sacred fire must burn, and the strength of our position is that, as has been demonstrated over and over again, it is the highest science, the most disinterested study, which are the most productive even in the narrow sense. We switch on our electric light, we speed along in our electric trams, we flash our electric signals through space and we bless the names of Edison, Marconi, and a host of other

¹ At the same time I greatly deprecate the use of the term 'civic university'. Universities should surely be cosmopolitan, and not parochial undertakings, like waterworks, for the supply of a merely local need. It is this attempt to play up to local patriotism which gives the new London 'Charlottenburg' some excuse for arrogating to itself peculiar 'Imperial' functions. I am thankful to say that the University of Leeds is limited neither in fact nor intention to the British Empire!

inventors, to whom indeed all due honour be paid ; but we are apt to forget that these men could never have been, had there not preceded them some dreamer of dreams, some one who cared for none of these things, some one who was more of a poet than a practical man, a Faraday working in a cellar with bits of wire and a compass needle, intent upon nothing but deciphering some page in the great book of Nature. It is only the ignorant, and among these many who pass for the most learned, and are so in their narrow way—it is only the ignorant, who think that science is harsh, malodorous, mundane, and unimaginative, and that we who follow it have strayed to the worship of the golden calf. We cannot stock our university with Faradays, nor should we wish to, but the teaching of science there, be it but the science of making soap—if it is to be worth anything, even for a sordid end—must be imbued with a high intellectual spirit and informed by a disinterested love of truth.

And there is another thing to be remembered. Set your mind, if you will, upon teaching a useful science ; you cannot do it usefully without teaching the related realms of knowledge. Begin with chemistry, and you must have physics ; you cannot have physics, but you must have mathematics. Nor must science be inarticulate, nor yet insular ; the cultivation of languages must accompany it. And then your students have to be taught before you get them, you have their teachers to train in all the liberal studies, and so arise literature, history, philosophy. Your hospitals beget a school of medicine and your courts a school of law. You cannot avoid becoming broad, if you but do what is plainly asked of you.

I have no fear whatever of our becoming narrow in our range of studies. In some thirty years we have passed from the Yorkshire College of Science, with four professors, to the University of Leeds, with thirty-two—not because of any sudden revolution, but from the natural growth of an institution

founded, as the words go, 'in particular to provide instruction in such sciences and arts as are applicable or ancillary to the manufacturing, mining, engineering, and agricultural industries of the County of York'. In the promotion of studies nothing succeeds like success. Kindle the intellect at any point and the fire will spread. You may be intent upon teaching science that is 'ancillary to manufacturing industry', but as your students grow there will be rebels who cry out for philosophy and Greek, because their hunger takes that form. The different tastes and aptitudes will assert themselves, and be they ever so remote from those you had in view, you find somehow that in gratifying them, you have added an intellectual light whose rays will reach and illumine the quarters where they were least expected.

I know of only one danger that may yet threaten our university, and I am happy to say that I think it remote. If any man, or body of men, should acquire the power to step in among us and direct that our teaching should comprise anything that partook of sectarianism, then indeed I should despair. It is a proposal that might come in a fair and an alluring form, but it is one which, in my opinion, should be resisted at any cost whatever. I am sure I need not enlarge upon this subject. I am sure I need not protest that to take this view does not necessarily imply a disregard of that third sphere of human activity to which I have so far hardly alluded, I mean the sphere of moral activity.

This leads me to the last part of my subject. In many ways the most anxious question connected with our new universities is this—what impress are they going to make on the whole man, on the morals and character of our students? I am willing to concede that we here touch the most important side of the whole question and face our greatest difficulties; but even here I am not the least disposed to repine.

No one who has the least knowledge of Oxford and

Cambridge in term time, and has had a glimpse of the life that may be lived in those surroundings, can fail to understand what is to be prized above all else in the ancient universities. The beauty of the place, the noble buildings, the traditions that they breathe, the great names of the past (and occasionally of the present) that stir the imagination; and then the daily life, at work, at play, the meals in stately halls, the quaint and ancient customs, the crowd of kindred spirits, the seeming religious background to it all. I have lived as a temporary don for a fortnight in a Cambridge college. It was not long, but quite long enough to enable me to understand partly and forgive wholly the exuberance of praise to which I have been compelled to listen all my life from my many friends who were educated at Oxford or Cambridge. I have been in Cambridge in May week more than once and seen the very flower of England's youth assembled there for wholesome pleasure-making. There is, I believe, nothing like it to be seen in the world, unless, of course, at Oxford. No one can wonder at the impress such communities make upon those who dwell within them, and no one can wonder at those who think that we have nothing like this to offer and never can have.

But, after all, Oxford and Cambridge had a beginning and so have we, and I for one am content to work for the future. I should not be content unless I could do so with good and well-founded hope. It is almost thirty years since I went as a student to Owens College, Manchester, and lived in lodgings in that great city. I cannot say that my sense of the beautiful was much exalted by my surroundings, though I think my sense of the need of beauty was very much sharpened. There was good music to be heard, perhaps the best in England; there were good plays to be seen, and there was some art; but altogether it was not what is called an 'atmosphere'. There was something of a corporate life outside the class rooms; there were games and societies,

and I formed friendships that have been lasting and, beyond words, precious to me. But I was conscious of the great lack of the place, and I used to build castles in the air as I thought of what might some day be. Well, thirty years have elapsed, and I have often revisited my old haunts with pleasure; but the greatest pleasure I have experienced has arisen from observation of the steady growth of those elements of student life which were most lacking in my own day. The change has been most marked and most salutary, and I am happy to say that I have seen a not less satisfactory change in the condition of things in Leeds. We have not moved far, but we are moving, and I feel sure we shall move with increasing speed.

We are at least industrious, and we are in earnest in our studies; we present few attractions and few opportunities for loafers. We who teach, live under the public eye; we are kept informed of our not too great importance in the world; our absurdities are kept within bounds; our extravagances are sharply criticized; our wise sayings, our sallies of wit, do not convulse a whole community; oddity does not give an enviable distinction; we are expected, we are, in fact, compelled to take some interest in our fellow citizens; we are called upon to take our part, often a healthy subordinate part, in all kinds of public movements; we are constantly meeting people who are our betters in everything except our own craft. We have, of course, some considerable disadvantages, for the time being at least. We are deficient in the appurtenances for study and research; we are greatly distracted by the administrative calls that attend the moulding of a new university; we are not very numerous, and we lack—though personally I cannot make this complaint—the vitalizing intercourse with men of our own crafts. Nevertheless, I will say for myself, and I am sure I might say it for many of my colleagues, I would not exchange my place for one in the university of Arcadia.

I regret most truly the ugliness of our surroundings, I regret that the young people who come to us cannot breathe unpolluted air, have their bumping races on the river, and wander in the pleasant woods and meadows that should surround Kirkstall Abbey. But we cannot have everything—at least at present. We have more than many people know of, and shall get more than many people expect.

The question has been raised as to whether our non-collegiate system of life (for our halls of residence are in their infancy), the absence of the kind of supervision which prevails in Oxford and Cambridge, and, above all, the proximity of a large city, where vice in many garbs strides flaunting through the streets—whether these things do not bring to our students risks that are vastly greater than those that attend life in the older universities. I cannot pretend to say with certainty. The new universities are of course mainly non-resident in character, and must long continue to be so. There is, however, a continual growth in the number of students coming from a distance. In Manchester, two prosperous residential halls, not very different in their regime from the colleges of the old universities, are already in existence. We have three smaller ones in Leeds, and I think there can be no doubt that these halls will increase in number and eventually contain a very large section of the student community, including, be it said, those who are poor in this world's goods. Of their importance there can be no doubt, and whilst we lack them we are defective in what many people will consider perhaps the most indispensable component of a university.

Meanwhile we suffer from the absence of what is of infinite value, or what may be of infinite value, in making our universities a training ground for character, and we cannot pretend that at present the impress made by three or four years of our university life is in kind or degree all that we could wish. Some merits in this respect we certainly have.

Our freedom from luxurious idlers is something for which we may be profoundly thankful, the representation of all classes of the community, of all sects, and of many nations, is, I think, excellent, and the co-education of the sexes has acted most advantageously on the morale of our community.

I have not the least reason to think that, as things stand, the moral tone of the new universities will compare badly with that which prevails in surroundings that would seem, at first sight, to be so very much more favourable than our own.

With manners—that is, with the part of manners that may be called art, it may be different. I am not one who makes light of the graces of well-born men and women. Who can be insusceptible to the charm of good breeding? Who will deny that there is some truth at least in the old aphorism, ‘manners maketh man’, in which manners and morals are included under one term. Aairs, affectations, exclusiveness, frigidity, the cynic smile, these detestable attributes of the snob who apes the gentleman, can be desired for no one—but good manners, they are something different. A spurious kind of manners, a simulation of good breeding, is so commonly the first warning of insincerity, that the real thing has become suspected and undervalued, and some people pride themselves on being blunt and bluff as a token of their honesty. This is a distortion, excusable perhaps, but not to be encouraged, and we must do what we can to add to our cardinal virtues as much as possible of the graces of refinement that give smoothness and sweetness to human intercourse.

Let us now ask again in conclusion—What is a university?

‘If I were asked to describe as briefly and popularly as I could what a university was, I should draw my answer from its ancient designation of a Studium Generale, or “School of Universal Learning”. This description implies the assemblage of strangers from all parts in one spot—*from all parts*; else, how will you find professors and students for every

department of knowledge? *and in one spot*; else, how can there be any school at all? Accordingly, in its simple and rudimental form, it is a school of knowledge of every kind, consisting of teachers and learners from every quarter. Many things are requisite to complete and satisfy the idea embodied in this description; but such as this a university seems to be in its essence, a place for the communication and circulation of thought, by means of personal intercourse, through a wide extent of country. . . . A university is a place of concourse, whither students come from every quarter for every kind of knowledge. You cannot have the best of every kind everywhere; you must go to some great city or emporium for it. There you have all the choicest productions of nature and art all together, which you find each in its own separate place elsewhere. All the riches of the land and of the earth are carried up thither; there are the best markets, and there the best workmen. It is the centre of trade, the supreme court of fashion, the umpire of rival talents, and the standard of things rare and precious. It is the place for seeing galleries of first-rate pictures, and for hearing wonderful voices and performers of transcendent skill. It is the place for great preachers, great orators, great nobles, great statesmen. In the nature of things, greatness and unity go together; excellence implies a centre. And such, for the fourth or fifth time, is a university; I hope I do not weary out the reader by repeating it. It is the place to which a thousand schools make contributions; in which the intellect may safely range and speculate, sure to find its equal in some antagonist activity, and its judge in the tribunal of truth. It is a place where inquiry is pushed forward, and discoveries verified and perfected, and rashness rendered innocuous, and error exposed, by the collision of mind with mind, and knowledge with knowledge. It is the place where the professor becomes eloquent, and is a missionary and a preacher, displaying his science in its most complete and most

winning form, pouring it forth with the zeal of enthusiasm, and lighting up his own love of it in the breasts of his hearers. It is the place where the catechist makes good his ground as he goes, treading in the truth day by day into the ready memory, and wedging and tightening it into the expanding reason. It is a place which wins the admiration of the young by its celebrity, kindles the affections of the middle-aged by its beauty, and rivets the fidelity of the old by its associations. It is a seat of wisdom, a light of the world, a minister of the faith, an Alma Mater of the rising generation. It is this and a great deal more, and demands a somewhat better head and hand than mine to describe it well.'

Such in the splendid prose, which mirrors the purity and nobility of his great soul, is Newman's best attempt to say what a university should be.

Can our new universities ever be such? I see them launched in a distracted world amid much that is good and much that is evil; I feel now the fair wind and now the foul; I have seen at one time men stint themselves of money, time, and health, to help us on our course, because they have thought we had a great destiny; I have seen at another time a man with money bags and transitory power asking an ardent professor of history what he was doing *for the trade of the district*. I have no claim to be a prophet, and I will only say that I for one am content to work in hope. Every thinking man must ask himself once at least if he is devoting his talent, however small it may be, to the worthiest task that he can reach, and he must decide as best he can. My only defensible claim for speaking to you to-day on the subject I have chosen, is that it is one to which from choice I devote the labour of my life, and one which engages the whole of my enthusiasm.

*Professors and Practical Men*¹

IT has been a fixed ambition of my life to play a worthy part in adapting education to the needs of the busy world. You will understand then—though I cannot believe you will understand fully—how deeply I feel, and how much I prize, the honour you have done me in placing me in the presidential chair of a society that consists of men engaged in directing and executing the business of a large and important section of British industry. My position arises, I know, from the circumstance that I have taken part in the establishment of a memorial to that great and noble man, George Livesey, who a short while ago was in your ranks and whose former occupancy of this chair makes it for ever a seat of honour.

I am sure that you will not expect from me more than is reasonable. You know (as, happily, I do also) that any attempt of mine to comment or generalize upon the great majority of the questions that concern you, would only lead me to disaster. Your work, I know, is full of anxious problems. The gas industries are in a state of tumultuous development; you do not know what a day may bring forth in the way of changes, great or small. Vigilance, enterprise, skill of all kinds are called for with an insistence that ever increases. It would be grateful to your ears to hear the voice of the true prophet, and to have an unquestionable forecast of your future tasks. Astrology and alchemy were, it is true, kindred pursuits, and it is said that modern chemistry is approaching alchemy; but I will not take upon myself to cast your horoscope.

¹ Presidential address to the Society of British Gas Industries, delivered at Leeds on March 3, 1911.

My predecessors in this chair have, each in his turn, talked to you of the subjects they have made their own ; and if I am to come near to them at all, I shall be obliged to talk to you on a subject which, so far as I can judge, everybody has made his own. You can hardly meet the man who is not prepared to talk about 'Education'. Even if he has had none, he is ready to say how much (or how little) he has missed it, or what it ought to have been if he had had it. It is often said there is no bore like the educational bore. The other day a very good friend of mine—an admirable and humane man—told me roundly he hated the very word education. I can well understand it ; but I bespeak your sympathy. If every man you met who used or did not use coal gas was prepared to offer you advice on the construction of a gasholder, you would no doubt suggest, more or less directly, that he might better mind his own business. But we whose business is education cannot do likewise. We have to sit and listen, with what patience we can summon, to every kind of public speaker or writer who chooses to open the floodgates of his eloquence upon us. But I suppose that if people only spoke in public about what they had studied, the hush that would come upon the world would be almost deathly.

I should like to put before you a few of the conclusions to which I have come after occupying for a quarter of a century a professorial chair in an institution which, in large measure, was designed to subserve the educational requirements of industry. At the risk of being thought egotistical, I will explain in the first instance that my father was a railway manager, and that I consequently passed my early life in an atmosphere of strenuous business, where, for mere amusement, I learnt the construction and working of a locomotive, how to manage a signal box, and did a number of other practical things. My first chemical experience was, in fact, in the rather odd work of analysing the fuel, oils, metals, paints, and other

things that pass in and out of the stores department of a railway, while I was still quite ignorant of the science of chemistry. During all this period, I was constantly associated with all kinds of what are called practical men; and the whole burden of that experience was to impress me, when a boy, with the belief that efficiency in the real business of the world bore no perceptible relationship to the processes called education as carried out in schools and colleges. Well-educated men seemed to be men who were interested in reading books in their leisure, or who talked in an interesting way about things outside their business. Sometimes they appeared in the form of mad inventors, whose futile designs were exposed with considerable triumph by my father.

Now I believe this stage of development, or, rather, its opinions, are those which, if they would but own it, a vast proportion of the people of this country hold at the present day; and I myself believe that they are not wholly devoid of foundation. It is undeniable that extraordinary practical success is sometimes attainable, in both manufacture and commerce, by men who have had almost nothing of what is conventionally called education; and these men are the hardest facts that we, who preach education, have to reckon with. But I will return to this subject later.

In my own case, after the period I have referred to, I underwent a long university training in this country and abroad, and committed myself eagerly to the academic career which I have since followed. The science of chemistry, as you are well aware, has played an extraordinary part in the development of industry during last century. There is hardly a branch of manufacture that has been untouched by it; but the most conspicuous example has been the creation of the wonderful industry based on the elaboration of the compounds contained in coal tar. When I was a student in Germany, this industry was in the full tide of development; and I witnessed the

continuous flow of the most highly trained purely scientific chemists from the universities to the works. I found likewise that, in other industries to which chemistry is applicable, there was a similar demand for scientific brains, and that in Germany as a whole there was a well-established understanding between science and industry very different from anything I knew of in my own country.

You are no doubt familiar with all this; you have heard it before again and again. I repeat it in order to show you how natural it is that English men of science, who have had experience of the system of things in Germany, should be profoundly impressed by its value to the nation. It is not surprising that they should loudly proclaim its excellence and commend it to their own countrymen. Yet it is very easy for people who are imbued by an enthusiasm for something discovered abroad, to forget two things—first, that transplantation is sometimes as difficult and as disastrous for political and educational systems as it is for living things. And, again, we are very apt in some circumstances to forget, or under-rate, the excellencies of our own peculiar possessions. When we are among the snowy peaks of Switzerland, or in the lazy sunshine of a southern sea, we may do scant justice to the quiet beauty of an English landscape or to the invigorating spirit of our stormy island shores. I am sure that, among the class to which I belong, there is a danger of under-estimating the deep-seated powers of Englishmen; of neglecting the true genius of our countrymen; and, in short, of falling into a narrow-mindedness which tends to put us out of sympathy with the people we desire to serve. I think that no one who has studied the history of our industrial development, or has moved observantly among our industrial community, can have failed to be impressed by the great native capacity of the Englishman for practical affairs. The quality is one exceedingly difficult to define. It is very elusive; but it is there—this power of doing things—a power

compounded of energy, shrewdness, enterprise, determination, sense of the fitness of things, and knowledge of the intuitive kind. Who does not know the man who, somehow or other, can get hold of the right thing; knows a good thing when he sees it; has an unerring sense of a wrong thing; knows when and where to buy a thing, when and where to sell a thing—who, in short, does not know a good craftsman; and where in the world will you find a better than in England? I honestly believe—nowhere. And yet it may be said that a man who is this and no more than this, is but a serviceable savage. I do not agree. He is a man who has developed one set of faculties; but it is a set by no means to be disparaged, by no neglect to be allowed to rust. I honour the man in his workshop who can tell by the look, the feel, the sense of a thing, what it is good for, as well as I can tell by the light of science from the intellectual eminence of a university. For I know that if he is really first-rate in his way, he can assess the value of things for which my science has yet no touchstone. It will be, I dare say, many a long day before an epicure can choose his vintage by chemical analysis; it will certainly be long before science can fully supplant the finely cultivated instinct of the true practical man.

I trust, therefore, gentlemen, that if I, a mere man of science, take upon myself to talk to you about education in relation to your own pursuits, I do not neglect that vastly important element of education, that development of mother wit, which comes to man as he fulfils his appointed task of wrestling in the world with men and things for his survival among the fittest. I am not going to emulate the action of a learned acquaintance of mine, who has recently taken upon himself to lecture the pioneers of aviation, because they have not delayed their heroic enterprise until the mathematicians have discovered the true theory of stability. Scientific men of this kind, if they had their way, seem to me most likely to achieve the

true practice of stagnation. I do not bid you cease to lay mains, to erect gasholders, or to make gas-fires, till we, in the august seclusion of our learned halls, have worked out the whole true science of heating and illumination.

But while conceding all this, we have to remember that it is man's prerogative, and it should be his delight, to possess, to use, and to extend the faculty of reason; to increase his power over the forces of Nature, and to constrain them to his service by a deliberate, a carefully organized, and an unceasing cultivation of the human mind.

The true barbarian is the man who is content to do, and does not want to know. And yet how many men are there not, whom no one could call barbarians, who look upon our organized system of education with a degree of distrust that increases in intensity as their survey passes upwards from the elementary school to the university? This, in my judgement, is a most serious question of the day.

I have long held the opinion that education in England is afflicted, from top to bottom, with an utterly exaggerated fear of what is called 'useful knowledge'. In that fear much of a vital kind has been left undone, and much has been given in the name of education which helps its possessor neither to truer wisdom, better work, nobler conduct, nor to greater happiness. The world cries out for educational bread, and it receives only too often an academic stone.

I do not know that I am behind other men in the delight I feel in abstract studies; and I can honestly say it is but rarely I envy another man his larger share of loaves and fishes. But knowledge gathered for what is sometimes called its own sake, and treasured for its own sake, seems to me in great danger of unwholesomeness, and a learned man who is merely a man of erudition, as likely to prove a mischief as he is certain to be a bore.

At the head of our educational system stand the universities. A university is (or should be), in essence, a mine and a mart for the highest learning. It was in its origin an adjunct to those callings which made the greatest demand upon the powers of thought. You may put it more picturesquely, no doubt, but it suits my purpose best to use homely terms; for I believe too little stress has been placed upon the real beginning, and the original purpose, of universities, as institutions standing in direct relationship to definite callings. It is, I believe, because our university system has not kept pace with the great changes that have taken place in the character of human occupations that universities have failed to secure, or to retain, the sympathy of a large section of the community. The great delay in the development of research and of instruction in Natural Science in the universities led to a corresponding delay in the dissemination of elementary scientific knowledge through our schools; and, in consequence, we find to-day in the older generation of our more educated citizens—to say nothing of the less educated ones—a whole legion of men whose knowledge of science would not correspond in terms of their grammar to knowing the difference between a noun and an adjective, in their geography the difference between latitude and longitude, and in their Latin to that between Cicero and Caesar. Now I lay great stress upon this lack of the general dissemination of scientific knowledge, because people sometimes say to me that, after all, we have surely had many distinguished men of science in our universities for generations past. It is true. But they were not preparing a market for their wares; they were elaborating in their seclusion something which was utterly mysterious to the average man. Even to-day people come occasionally into my laboratory with the air of men entering a hall of mystery or a chamber of horrors, fearful of what may befall them. Again, people say to me, surely the

industrial fruits of scientific knowledge have long been recognized? True again, most palpably true; but how the fruit is related to the knowledge, how the seed is sown, how it is tended, what should be done to nurture the plant, that is not known. It is not known because your educational system did not achieve this one thing for the community—it did not put its victims for a single occasion in their lives in the position of asking a simple scientific question, and of faithfully finding the answer by experiment.

Now the portion of knowledge which most completely and most vitally interpenetrates our manufactures is Natural Science; and it has been, I think, an incalculable disadvantage that while these manufactures were advancing by leaps and bounds during the century succeeding the industrial revolution (which I suppose may be dated about 1760), there was no movement in the educational world for a general dissemination of scientific knowledge and skill. During this period, several misconceptions took deep root in the English mind. The achievements of Arkwright the barber, Hargreaves the weaver, Crompton the farmer, Watt the instrument maker, Cartwright the clergyman, Stephenson the fireman, Murdoch the millwright, and of all that illustrious group—their great and fundamental achievements created an overwhelming belief that the self-taught inventor was destined to be the only important pioneer in industrial discovery; and to this day a young man brought up on a diet of grammar and Samuel Smiles might well despair of contributing anything of moment to the service of industry, unless indeed he happened to be exceptionally poor and to have attended no more showy a place of education than a night school.

If the universities had set themselves to send a current of science through our schools at the time when the direct utility of scientific knowledge and of scientific method was becoming demonstrable in the industrial world, we should, I think, be

in a very different position to-day, and our universities would hold a very different place in the esteem of our countrymen. It is this historical retrospect, and the experience of the frantic and wasteful struggles in my own lifetime on the part of the worker to come to terms with the thinker, that have made me realize the dangers that attend academic seclusion, and have left me well content that my lot as a university teacher is cast within earshot of the throb and hum of busy work-shops.

Of all that we have lost in the course of the events I have described, nothing is more difficult to retrieve than confidence in the practical usefulness of university science. We are suspected at every turn of trying to elude the practical man, and to betake ourselves to studies, and impart information, whose glory lies in their detachment from all things mundane and remunerative. We have engendered the suspicion that we are intellectually exclusive, and that we do not understand or sympathize with the practical point of view. A better understanding between us is, I think, a matter of the greatest national importance; and it has seemed to me that if a better understanding is to be obtained, it is incumbent on the universities to go out as far as ever they can to meet the legitimate claims of the industrial community, and to bring their studies deliberately into the closest possible relationship with the industrial arts.

I think I may claim that in this university we have shown no lack of courage in doing so. In spite of a good deal of academic apprehension and distrust (not always kindly expressed) from outside critics, we have established departments of work for the explicit purpose of furthering the special pursuits of industry, much in the same way and in the same spirit as schools of law, medicine, and theology were established in bygone days. Another thing on which I would lay the greatest stress, is that we have secured in

the direction of our university as a whole, and of these special departments in particular, the active co-operation of men of business and of representatives of the particular industries concerned.

I do not look upon these steps as a gracious concession, still less as a sordid opportunism. I believe that they secure the best interests of thought as surely as I hope they will serve the most immediate needs of work.

No one who has studied the history of science can be ignorant of the fact that science has its roots and has gained its greatest impulse in the practical avocations of mankind. Chemistry was born in foundries and pharmacies, and nearly every great advance can be traced to some industrial impulse. I suppose the greatest achievements in chemistry were those of Lavoisier. How did they arise? I believe I am not wrong in saying that it was in the preparation of his prize essay on the best mode of lighting the streets of Paris. Beginning with a consideration of the best form of lamp, the most effective form of reflector, the most suitable shape of oil-container, Lavoisier passed to the study of combustion, and, finding organic things like oil and tallow too complex to reveal the fundamental nature of the process, he betook himself to simpler things like phosphorus and zinc; and so he was led to the train of discoveries which constitute the foundations of modern chemistry. 'It was', as M. le Chatelier has said, 'this constant preoccupation with practical questions that enabled Lavoisier to escape without effort from the fictions and conventions amid which contemporary chemists were merely marking-time.'

I have given you but one of innumerable examples to illustrate a truth that we who profess science should never be permitted to forget, and to assure you that I regard the close association of universities with the business world as of enormous advantage to the universities. We have in this,

I believe, the true corrective of academic excesses, the best stay for academic frailties ; and I believe the good understanding and mutual respect which we may hope to bring about between the leaders in the spheres of labour and of learning will extend rapidly through the rank and file.

I hope you will find in what I have so far said, the evidence of a desire to acknowledge some of the shortcomings of the academic world. But I might well be suspected of having had my head turned by the dignity you have conferred upon me if I left you under the impression that I thought the faults were wholly on one side. In what remains of the time at my disposal, I wish to confide in you some of the difficulties of the situation which arise from the other side.

I believe that a very large number of business men go wrong, when they enter upon the consideration or criticism of educational affairs, by attempting to apply methods and standards and principles borrowed from their own callings, which, however excellent in their proper place, do not apply (or at least do not apply in the same way) to education. Let me remind you in the very first place that you can, for example, prepare no balance-sheet of a university. You know how much money comes into the university chest and how much is paid out ; but how much a university costs, or how much it earns, no man can discover. Suppose, for example, in my zeal to find employment for a student, I send you a young chemist, who, by his unrestrained ardour or incompetence, misleads you into all kinds of futile extravagance—surely you would debit that to the university? I do not doubt you would ; every care is taken that such things are brought home to us! Suppose, on the other hand, that I send you some one, like a former student I met last week, who, by what he had learned here, increased the output of his employer's business by 33 per cent. Should this not be credited to the university—if by some one's indiscretion you

happened to hear of it? I think so. In a business like ours, it transcends the powers of any accountant to effect an audit; you would need a whole secret service of educated spies. You, individually, may give us a thousand pounds in the hope of a return; but you, individually, may get nothing in return—at least in this world—or you may get a return that you cannot trace to its source. No; the essence of university finance is collective investment. It is to some considerable extent selective for a locality, and may be made equally so for a single group of interests or industries. But looking at a university as a whole, it is national or even international in its financial ramifications.

If I and many of my colleagues in this and other universities are of some value to this country, I would have you remember that the cost of our education has, to a quite considerable extent, fallen upon the German taxpayer.

If I say that the students who have gone from our Chemical Department are collectively earning half a million a year for the firms who employ them, no one can contradict me; and I am tempted to affirm it positively, as a counterblast to those hasty financiers who look at our accounts and raise their voice in lamentation over the capital we lay down, without ever stopping to think of the unrecorded dividends that accrue.

I will take another thing. I think a good business man, while anxious to progress and branch out, while ready to take risks and go somewhat afield for promising expedients or appliances, is usually very careful not to lose sight of the main current of his affairs—expecting to profit by deliberate, methodical plans rather than by totally unexpected accidents. The same is doubtless true within the pursuit of science itself where the object is simply to elucidate a given problem. But when it comes to the contact between science and industry, an entirely new factor appears.

The discovery of the atmospheric burner was not an accident. It arose from the desire of Bunsen to have a gas-flame that would not smoke his flasks; and it was contrived by a stroke of genius. But what an accident for you that a man of genius should want a smokeless flame! When I was a student in Bunsen's laboratory, there came to it Carl Auer von Welsbach, in the spirit of an unalloyed philosopher, eager to solve some problems about the group of chemical elements that seemed, of all, the most remote from any daily human needs. He noticed the remarkable glow of the mixed oxides when a flame impinged upon them. And so he begat the gas-mantle. Again I say, no accident for him, but again what an accident for you, that a man of genius should want to investigate the mystery of rare earths!

I need not ask you where the gas industry would be to-day without these windfalls from the tree of scientific knowledge, whose branches, be it remembered, wave most vigorously in the upper air. Instead of in this assembly of comfortable gentlemen, enduring so kindly the garrulity of a professor, you might perchance have been found in Trafalgar Square, listening under the banner of the unemployed to more moving eloquence.

By what definite planning are you to get discoveries of this kind made? The answer is, I think, by treasuring your men of genius, and letting them work in the light of their genius. Surely the time has gone by to wonder whether true scientific work, carried on in the spirit of a philosopher, by a man of genius with his feet upon the earth, subserves the material needs of humanity. Who is there that will dare to set his finger on any patch of new natural knowledge and say: 'This may be edifying, but it is nothing to us'?

When, therefore, you seek to bring science into your service, beware of unduly fettering the minds and discriminating the topics. This seems to be the hardest lesson of all for the

Englishman to learn. His very straightforwardness and stern common sense, and his businesslike ways, may all conspire to make him unbusinesslike in matters of education and research, to which, believe me, a man must serve a long apprenticeship before he becomes a master craftsman. I will listen eagerly to a business man while he tells me what he wants; I will eagerly seek the real knowledge that he has to give; I will eagerly lean upon him in the manifold business of administration; I will eagerly take his money. But when he wants to tell me that I shall teach this and not teach that; that this is useful, the other useless; above all, when he talks as if a well-constituted university should give proficiency in the practice of trades and render apprenticeship superfluous—well, I do not listen to him very patiently, and I say to myself, ‘Alas that this man should think himself practical!’

If we on our side come to take a more sympathetic and direct part in bringing science to your service, I plead that you on yours shall show a larger measure of faith, of hope, and, I might almost say, of charity. Do not try to constrain us in our own proper business; do not be impatient of returns. They are sure to come—history has abundantly proved it; but you must freely cast your bread upon the waters.

I have chosen in this address to take what may be called a materialistic view of education, and I am not ashamed. I do not forget that education has many purposes to serve, and that man does not live by bread alone. But without bread man becomes a shadowy or a rebellious being; an ascetic or an anarchist. He must have bread, and he must get it by the sweat of his brow. Englishmen collectively must have work; the nation must have industries; and I take it as no degradation of education to contrive that it shall minister directly to their preservation, their progress, and their prosperity. Rather would I say this—that thereby you dignify labour, refresh the toiler with the fruits of knowledge, and infuse into

his daily work the delight of seeing beneath its grime and dust a play of stupendous forces within majestic laws.

Of all the men whom I have known, I could point to no one who more completely than George Livesey embodied the finest native strength of the English industrialist. He was one of those men to whom I referred at the beginning of this address, who was bound to succeed independently of all that we call formal education. But you know that he never breathed any such vulgar boast. On the contrary, he believed with all his heart in the worth of all things intellectual. He was eager to draw to his aid all the resources of modern science; he took the broadest, most sympathetic, view of scientific research; and I can, as I have said before, imagine no memorial more acceptable to him than the one which to our great honour you have set up in this university.¹ In the inspiring address which he delivered to you from this chair three years ago, he lifted your thoughts to the ethical side of industrial life, and preached to you the chivalry which you know he had practised in his life. Honest dealing, confidence between man and man, care for the workman, national before personal interests—in short, a large-hearted humanity—these were his topics as they were his qualities. I am not without hope that in the universities old and new, where knowledge should be cultivated, whatever it may pertain to, in the worship of truth, where young men should see visions, we may help to maintain the fine flower of British industry, of which George Livesey was so splendid an example.

¹ The Livesey Professorship of Coal Gas and Fuel Industries.

The Relation of Universities to Technical and Professional Education

THE subject which I have the honour to bring before this meeting raises certain large and fundamental questions of university polity, which have been agitating many minds and which deserve serious consideration, and I think it will be more useful if, instead of attempting to give historical or statistical information, I direct the attention of the Congress to the broad considerations which affect the relation of universities to what is now commonly understood as technical and professional education.

In outline, the situation may be described in the following way. Professions and business vocations are more and more becoming learned callings, each developing a special body of knowledge, which requires for its full mastery and effective use, an intellectual training of what may be called the university standard. The special training so required is, for what are known as the learned professions and for some other callings, already provided in universities. In the case of law, medicine, and theology it has been provided from the earliest days of universities; in engineering and agriculture it is comparatively new: in commerce and chemical technologies it is hardly of yesterday.

Outside the universities, the training and the intellectual standards, which are deemed essential for certain callings, are often regulated by associations of people representing the particular interest concerned. This is, of course, still partly the case with medicine, law, and theology. Associations of

the kind frequently set up the standards, enforce them by examinations, but do not provide any training. Such, for example, is the case in this country with the Institution of Civil Engineers and the Institute of Chemistry. Further, we must note the existence of a great variety of special training schools with professional or technological aims, where a portion or the whole of the work is of university standard, but where there is no direct association with a university or with an incorporated body representing a single interest. Lastly, there are affiliation arrangements for the inclusion of technical studies.

The next fact that I wish to emphasize is that the authorities who govern these outside institutions and associations are, to a large extent, men engaged in the particular calling concerned, and are not primarily academic in their interests and outlook. In some cases a municipality is the governing body. It is to be expected that in any readjustment of educational plans the existing governors will be tenacious of the authority they have already acquired.

The question now is, What should be the attitude of the universities in this complicated situation? They do not stand outside, they are already involved in it; they cannot refuse to be interested. It concerns especially those newer universities which are still developing a fundamental policy.

The main difficulties of the position appear to me to be these. On the one hand, it may be supposed that those who are primarily interested in special studies, would be very glad to secure for them the certain advantages which come from incorporation in a university. They can hardly refuse to acknowledge the benefit to all young men standing at the threshold of their life-careers, of the humanizing life of a university, with its great variety of individuals and interests, its broadening influence on intellectual outlook, and its potent effect in the formation of ideals and of character. They fear, however,

lest the committal of their interests to the academic government of a university might mean the loss of their own influence and the sacrifice of a vital element of reality in the studies themselves.

On the other hand, the universities cannot fail to recognize the growth of new studies and new demands, differing in no easily definable way from those they have already recognized and met. Yet the number of these new studies and demands, the particular character of some of them, and, above all, the prospect of greater intrusion of the outside world in the regulation of university studies, give cause for reflection, hesitation, and, it may be, alarm.

I think there is no doubt that amid much activity in the institution and recognition of technical studies by our universities, there still lingers in many minds a doubt as to the validity of the claim of applied science for a place beside more ancient subjects. This doubt, when it exists among the representatives of the traditional humanities, is not nearly so serious an obstacle as when it is entertained by the votaries of pure science; for whilst the humanist will frankly avow his dislike of these 'utilitarian' studies, the man of science may declare his entire disbelief in their utility, and claim that the industrial arts are sufficiently served by the unpolluted streams of pure science. A change of opinion is, however, taking place, and the exclusive man of science is being forced to recognize that there is a whole realm of specialized knowledge, lying immediately outside his own domain and in close juxtaposition to the industrial arts, which may fitly engage the highest intellects to explore, to extend, and to impart, and which in every respect has earned its title to university recognition.

In discussing the present situation, I think it will be best to face at once the fundamental question: What constitutes the fitness of a study for university recognition? It is a question

not often publicly discussed, but it constantly comes before those who are concerned with the organization and management of higher education, and there is no doubt that it gives rise to a good deal of strong feeling. We are constantly thrown back upon a consideration of the legitimate functions of a university.

On this subject much has been said and much may be said; but if we desire to be brief and summary, I do not think we shall easily find a better declaration than is contained in words used by our Chairman. Speaking of a university, he says, 'A fourfold duty lies upon it: to provide the best teaching over the entire field of knowledge of which its own resources and the progress of science may admit; to offer this teaching to the widest range of students; to mould and shape them not merely by the training of intellect, but by the discipline of spirit, so that, wherever they go, they may be worthy citizens or worthy servants of the State; and to extend by original inquiry the frontiers of learning.' (*University Reform*, Lord Curzon of Kedleston, 1909, p. 210.)

These words are used expressly in relation to 'a university so historical in its character and so majestic in its influence' as Oxford. But I think we shall say that they define the proper functions of every university, and that any corporation styling itself a university, which does not mean to abide by every one of these articles of faith, is guilty of taking a name in vain. The newer universities, so far as I know them, are just as ambitious, and just as high-principled as the old; and they would scorn with equal fervour the worship of false gods. They are, it is true, young, and for the most part small and greatly lacking in amenities; yet universities they are, and each one of them hopes, I imagine, under the blessing of Providence, to become in good time a mighty instrument of wisdom and enlightenment.

It is therefore no solution of the question of the fitness of doubtful studies for university recognition, to suggest that

they may be relegated to the young institutions, if this suggestion is made, as I am afraid is sometimes the case, from a feeling that these places after all have not much of a character to keep up. On the contrary, if certain studies are essentially alien to the purpose, or derogatory to the dignity of a university, they should be excluded with especial rigour from universities that are handicapped by the frailties of youth.

Only one thing could be worse—to propose a segregation of these doubtful studies altogether, because they are doubtful; to put them upon the suffrages of the Philistine; and to let them proclaim their money-worth in the market-place, to all who are eager only for what they conceive to be the utilities of knowledge.

What is it that lies behind this suspicion of the studies that are in question? It is undoubtedly the belief that they are in their nature mercenary; mercenary because they are meant for direct application to the occupations of life. It is, in fact, the old, old question of bread-and-butter studies. Narrow, pedantic, and mischievous as, I think, is the spirit often associated with this jibe, I respect the apprehension that underlies it; and if I believed that the embodiment of technological and professional studies would depress either the intellectual or ethical standards of university life, I should, I hope, never raise my voice in favour of such a policy.

We treasure, and justly treasure, the ideal of a university which, in the past, has been appraised again and again in the finest and sincerest eloquence of our worthiest men. I hardly know how to follow their words with any language of dissent that will not seem impertinent; yet I must confess to never having felt the justice of praise bestowed upon the feature of detachment, which in the past has been so characteristic, especially, of English universities. I am, of course, aware of the force of certain influences which are specially favoured by seclusion

from the world, just as I am aware of the dangers which beset any individual or institution that becomes embroiled in the strenuous life of our feverish Western nations at the present day. But I do not think that any thoughtful person who has spent his years, say, in the North of England, can have failed to discover and deplore the great lack of sympathy and good understanding between the educational and industrial communities, and to seek for the cause of this estrangement. I can only give my own explanation. I do not believe that the cause lies in the turpitude of the industrial world. I have no sympathy with those people who can see in the industrial life nothing but a sordid struggle for worldly success and wealth. It is a distorted and an unfair view. The amassing of money is no doubt an inevitable incident and the readiest measure of success in industry. Truly enough, it is a consuming purpose with multitudes who are under the stress of hard necessity. But exactly the same is true of the learned professions. There may be more sordid souls among the leaders of industry than in the professional world—I express no opinion—but as well in industry as there, the achievement, and, to all right minds, the glory of success, come from the conquest of difficulties; it is this same zest to do right things well, and it is not cupidity, which is the sustaining force of our manufacturing world. Such at least has been my observation.

The fault, I believe, has lain rather with the educational world. It should have led, where it has tardily followed. If educational institutions are to preserve their influence on the people, they must alter their ways with the progress of civilization, in some measure, as the people alter theirs; they must be ever alert not to get detached. But how difficult it is! At one time mankind inaugurates a system well adapted, it may be, to the conditions of the time. The system becomes dear to its generation; people who have profited from it proclaim its excellence, recommend and enforce its claims upon their con-

temporaries and their successors. As years roll on it acquires the added graces of antiquity and becomes something almost sacred, something that would be profaned by change; until at last it is found to be standing hopelessly apart from the human needs it was intended to subserve. For happily humanity itself is progressive; change, unceasing change, is the law of progress, and what fitted the conditions of life a century ago cannot be expected to fit them equally to-day. These remarks apply, I believe, with full force to education, and it is surely incumbent on us to be continually asking whether our educational system is in conformity with the conditions and legitimate needs of the day.

The universities stand at the head of our educational system, and from them flows the intellectual streams to irrigate the plains where men do their varied tasks. It is at the universities that all types of education should receive their sanction and their inspiration. It is not for universities to fold their arms and say, '*j'y suis, j'y reste*', and to look with disdain upon the efforts of the multitude to get for themselves through the zealous aid of Government officials, municipal authorities, and men of business, something adapted to their new intellectual needs and appetites—something they cannot find in the rigid articles of their educational hierarchy. If the universities do this, they may, indeed, preserve a splendid isolation and do great things in many ways, which it is my last wish to belittle; but they will leave undone what is essential if they are to exert their proper influence, and if the balance of life is to be preserved between thought and action; and they will continue to divert from industry intellectual talent that is born in it, and that would go back to strengthen, enlighten, and ennoble it if the talent were well directed, and if it found that in the high courts of learning even technologies had an honourable place.

The isolation of professional or technological studies, and

their cultivation in separate institutions, seems to me to be fraught with serious dangers and disadvantages. In the first place, countenance is given to the mischievous tendency to distinguish between useful and useless knowledge. An entirely artificial cleavage is produced in the whole body of learning, which prevents that reaction between teachers, students, and studies of different types that is so potent in correcting extravagances, in extending the mental horizon, in producing breadth of intellectual sympathy, and in giving a well-adjusted culture to the whole human being. It would, I think, be difficult to overstate the importance of the influence which comes from the close association, in a place of learning, of people of widely different interests and destinies. It means more than one can well say. It is at the basis of what we call liberalism in education; it is the thing which works equally against pedantry and venality; it is more than intellectual, it is spiritual. It is, I believe, all-important and indispensable if we desire to imbue the rising generation with the true perspective of knowledge and of life.

I am well aware that the cultivation of technical and professional studies in separate institutions is favoured by some high authorities and is the accepted practice of some countries. I can well believe that it has some advantages of convenience and may conduce to a certain kind of efficiency. Efficiency we certainly desire; the close union of specialized knowledge with the practical arts is now a necessity of national existence. But national well-being depends in the end on something much deeper than intellectual efficiency and technical skill. We want first and foremost men of character, understanding, and ideals, and in the organization of technical and professional training, as in all educational enterprise, this is a primary consideration to which sacrifices may be cheerfully made.

For these reasons then, positive and negative, I am an earnest advocate for the actual embodiment of professional and

technical studies in our universities. It is there that they will find not only abundant springs of intellectual nourishment, but also the influences that will keep them expansive and wholesome. It is there that they will bring a much-needed bond with a vast section of the working world, and help to keep in check extravagances which are the opposite of their own.

It is, of course, not suggested that each university should attempt to cope with the whole range of professional and technical studies. Among them they may cover the whole field, each university addressing itself to the particular studies which local or other conditions determine as appropriate. This division of labour, accompanied by freedom of interchange of students between universities, would greatly promote both economy and efficiency, and would prevent any undesirable predominance of technical and professional studies in a single institution.

The policy which I have advocated in this paper has been fully embraced by the university with which I am connected, and, in conclusion, it may be of interest if I refer to some questions of detail in connexion with it, which have forced themselves on my attention.

I have alluded in an earlier part of this paper to the existence of a number of associations representative of various professions and industries, which have among their objects the regulation of the training and the intellectual standards which are deemed essential for their several callings. It seems highly desirable that the interest and the experience of such associations should be brought in to aid the universities in the organization and control of those departments which are concerned with technical studies. There seems no more reason, for example, why, in a subject like Engineering, the organized bodies of the profession should not participate just as much in the regulation of university studies of that subject as the medical profession does in effect in the study of medicine. And the

same thing applies generally to organized bodies, which are deeply concerned in the education that is preparatory to the calling that they represent. This idea has, I believe, only been realized to a very small extent; but in some of the newer universities great importance is attached to the co-operation in the administration of departments of applied science, of Advisory Committees, consisting of men for the most part actively engaged in the industry to which the applied science is related. At least one case may be quoted where such an Advisory Committee is composed mainly of representatives directly delegated from the professional associations representative of the whole industry concerned. The gain to the university of such relationship is very great. Not only does it bring with it a large amount of valuable advice to the service of the university, but it breaks down the barriers which are so apt to arise between academic and practical life, and ensures that there shall be a vitalizing contact between the university and the world outside. The extraordinarily rapid transformations which industries undergo at the present day, lead to the danger of a teacher becoming out of touch with current developments and new needs, if he is isolated within the precincts of a university. His intercourse with industrial leaders is greatly facilitated by the existence of such Advisory Committees as I have referred to. The limits of the authority of such Committees will, of course, be regulated by the university, and care will be taken that their intervention does not proceed beyond due limits. They should be, in academic matters, as their name implies, rather advisory than executive.

The difficulty of securing suitable teachers of applied science is no doubt very considerable. Whilst it is essential that such a teacher should have a first-hand knowledge and experience of the industry towards which his teaching is to be directed; and whilst he should keep in mind industrial needs and industrial demands, and maintain a sympathetic interest in the

point of view of the man who is limited on every side by industrial and commercial conditions, it is no less essential that he should be as much an enthusiastic lover of knowledge and an eager seeker of new truth as any other teacher. The qualifications of an ideal university teacher of applied science are, indeed, more complex than those of any other class; and having regard to the temptations by which such a man is beset to commit himself wholly to an industrial career, it must be regarded as a stroke of good fortune when he is secured to a university. But when the right teacher is found, he may be trusted to maintain the intellectual prestige of his subject, to keep it in every way worthy of its place in the university, and to be scrupulous in regard to his own professional relations with the calling in which he is an expert.

The creation of faculties within a university seems to be almost inevitable for various purposes of administration, but it is well known to be attended by certain risks. There is a tendency in the deliberations of a faculty, for questions to be viewed too much from a single standpoint, and it is not easy, when a united opinion has been formed in this way, to avoid a certain amount of friction when the same question intimately concerns two separate faculties. For such reasons there is much to be said for maintaining applied science in close association with pure science. A fusion of the two faculties for all deliberative purposes has seemed, in my own experience, to be of the utmost advantage.

With regard to the question of degrees embodying applied science and the curricula related thereto, there is no doubt a good deal of difference of opinion. I am, for my own part, strongly averse to the multiplication of degrees, and cannot help regretting that so much differentiation has already taken place. It seems much more important that a degree should mark a state of maturity rather than a special kind of proficiency, and I have a fear that great variety in the names of

degrees will lead to much public confusion. I can see no objection to giving a qualified student of applied science a degree in science without further modification of the title. But the matter is, perhaps, of no very great importance.

With regard to curricula, the introduction of applied science creates some difficulty, owing to the number of contributory studies which claim a place, and the reluctance which every teacher naturally feels to see his own subject either excluded or reduced in range. It is, however, an inevitable consequence of the growth of knowledge and the rise of new studies of all kinds, that some sacrifice of the old must be made, that the range of preparatory studies must be restricted, and that they must be reduced more to their philosophical essentials. It is, however, a great mistake to suppose that the disciplinary element and intellectual depth of scientific knowledge are reduced when we pass from pure to applied science, or that a curriculum which extends over three or four years and includes a large measure of applied science, stands in any but the most pedantic sense 'below' any other university curriculum of equal length.

It is no doubt justly held that the besetting danger of specialized education of all kinds is the neglect of preparatory studies and fundamental sciences, without which, technical knowledge, however elaborate, is inanimate and sterile. It is here that what may be called the academic weight of a university affords a safeguard that can hardly be overvalued.

There are many other questions of importance which arise in connexion with the subject of this paper, and I am well aware that my treatment of it has been meagre and incomplete: but I have been intent mainly upon the advocacy of a general policy, and I have no doubt that those who follow me in the discussion will bring forward questions which I have omitted, and on which, from their own special experience, they can speak with much greater authority.

*Science and the Press*¹

EVER since I read the newspaper account of my first public scientific lecture I have looked forward to an opportunity of addressing journalists on the subject of science and the Press. Now that the opportunity has come, I find that time and experience have so mellowed my feelings as to rob the occasion of the dramatic interest that it at one time seemed to promise, and if I do not come to praise, I have at least no longer a concealed desire to bury.

I have certainly come to understand how exorbitant are the claims which are made upon the journalist. He belongs to a class of men who ought to know everything. Journalists are something like architects or housewives. An architect should be an artist; a surveyor; an engineer, civil, mechanical and sanitary; a man who knows all about wood, metal, brick and stone; a financier; a manager of men; and I know not what beside. Well, you know an architect is never all this, and rarely any part of it to perfection; yet he is often a wonderfully good architect. I have not time to enumerate the qualifications of a good housewife. Perfection in them all is unattainable, but Heaven be praised, there are still excellent housewives.

A journalist's equipment would, I imagine, be even larger than that of either of the two classes I have named, if he were to be fully qualified to understand the things with which he has to deal. I realize now, therefore, quite clearly, that if a journalist were sufficiently scientific to be able to report my lectures with the fullness and appreciation of which I at one time thought

¹ Address to the West Riding District of the Institute of Journalists, delivered at Leeds February 9, 1910.

them worthy, he would probably have lost the balance and catholicity of mind which are only secured by knowing a uniformly limited amount about a very large number of subjects.

In this respect the journalist resembles the English Minister of State, and I believe the similarity is not accidental. It is a well established principle in the construction of English Ministries that a statesman shall be fit for any office. With perfect complacency a man, who could not be trusted to navigate a canal boat, undertakes supreme control of the British Navy, whilst another man, with a private taste for moral philosophy, becomes Minister for War. Either may be called upon to become Chancellor of the Exchequer or Colonial Secretary at a moment's notice. It would probably be considered dangerous to put a real specialist at the head of any department of the State. What is desired is that a statesman shall not be a narrow man, who will be without a sense of proportion. He must not have the partiality of an enthusiast, nor be carried by special knowledge too much in advance of public opinion.

I imagine the same reasons hold in the case of the journalist: his most fundamental requirement is that he should keep in touch with public taste and public opinion. And so I have come to sympathize with him in his difficulties, and to share the general admiration of the way in which he does his multifarious work. I have often been struck with wonder at the seemingly instinctive way in which he will extract what the public wants from large collections of what it may need, but doesn't want.

Generally speaking, then, my old grievance is gone, or, perhaps, I should say it has assumed a different form, for I still think the Press negligent of science. But then I think the whole nation negligent of science, and if the function of the Press is to reflect public opinion, I think it reflects it very fairly in the matter of science.

How long will it be, I wonder, before science comes to its own in the general education and the general economy of the nation? One would think sometimes from what people say that science had gained its place. Believe me, this is not the case. A good deal has been done; science appears in our curricula, and is a great deal more respectable than it was; but it is still quite a prevalent opinion that a man may be styled well-educated and not know any science at all. It would occasion no surprise if in the whole British Cabinet there were not enough science to pass one member of it through a matriculation examination. This would not be so bad were these people not impenitent. A remark was quoted to me the other day which I believe to be typical. It came from the lips of a Member of Parliament of distinguished literary position. He said, 'I don't care twopence for science; I don't know why water does not run up-hill, and I don't want to know'. Now, of course, the feeling behind this remark is merely that science is a mechanical and soulless thing, and that with all human history, human literature, human society, and human nature to study, one may well be excused from spending time in learning about the laws of the inanimate world. Of course our friend was speaking in ignorance, and his remark was exactly on a par with those we so often hear about the futility of classical studies. What does it matter to a soap-boiler or a surgeon who won at Marathon or Salamis? But then our friend was thought merely to be smart and amusing when he gloried in his ignorance of science, whereas if the soap-boiler or the surgeon had merely said Salamis instead of Sálamis—what then? Think of the sniffings and shrugs and glances that poor uneducated man would have provoked.

Now I have no sympathy whatever with a contemptuous attitude towards classical or literary studies. All I wish to say is, that until science is treated with as much respect as the older subjects of study, it will not have come by its rights.

This respect it does not receive. It is still looked upon with a good deal of distrust by the theologians: it is not taken seriously by the typical headmaster of our public schools (of course it is in the curriculum, but it is not in his heart); it has a miserable position in the Departments of the State; it is not appreciated in the business world.

This being the case, it is not very surprising to find the position it occupies in the Press. Yet the Press does a good deal more than reflect public opinion. Take art, for example. What standard of opinion is adopted there? Imagine a newspaper critique of the Royal Academy, accurately reflecting the public opinion on art derived from the majority of its readers! No, in art, in music, and in literature the Press aspires to the rank of expert and guide; it holds up an ideal to its readers, and readily prints columns of technical criticism that must seem strange stuff indeed to the overwhelming majority who do not read it. A newspaper would think it discreditable to commit any solecism in dealing with these matters.

In science it is entirely different. I admit, of course, that the public does not want science. It likes to hear about the North Pole and the Comet, because it is stirred by the hazards of our seeking the one and the hazards of our being sought by the other. It likes to hear about the price of radium and the progress of modern alchemy. It is interested when some man of science takes to amateur theology, or when another says the coal supply is getting exhausted.

Pray do not suppose that I am taking a superfine pose and sneering at curiosity, which, if somewhat trivial, is quite natural and harmless. I know there are vast numbers of people who are more interested in reading those graphic accounts of how the Prime Minister 'entered the House smiling and stood with one hand on the brass-bound box' than in the momentous speech, which intervened before he 'resumed his seat and chatted pleasantly with the Chancellor of the Exchequer

resplendent in a new suit of Welsh Flannel'. What I complain of is that science is not taken in hand sufficiently seriously by the Press itself, and that in addition to giving the public what it wants, it does not hold out a higher ideal of scientific interest. But I go further than that—I am obliged to say that even in giving the public the oleograph and brass band sort of science which it appreciates, very few newspapers are in a position to protect themselves against publishing inaccuracies of the most glaring kind, and broadly speaking when I see a scientific news paragraph in a paper (I do not mean an article)—well, I am prepared for anything. Let me give one or two illustrations of what I mean. Here for example is a paragraph headed 'A Scene at a Mudborough Committee.' 'In consequence of a difference of opinion between Alderman A—— B——, the chairman, and Mr. C—— D——, the vice-chairman, as to the method of producing formic sulphate, the Chairman left the room and the business had to be adjourned.' Now what is there wrong here? Only this, that there is no such substance in heaven or earth as formic sulphate. You will observe they adjourned the business, and I don't wonder at it. Here is another—this time from a paper whose title suggests the very opposite of fiction. It is one of those feminine letters from a lady of fashion, which I understand are usually composed by elderly gentlemen. It extols a gas stove for which it says no flue is required for carrying away the products of combustion, 'for the very sufficient reason that there are no such products, combustion being perfect'. Here is a calm enunciation of the destructibility of matter. Again, from a London daily: 'The theory advanced by Mme. Cavalier in a lecture on Thursday that diamonds have sex, and if placed together in a box will multiply, is described by Professor Pringle, of the Museum of Practical Geology, South Kensington, as absolutely untenable. All jewels are the result of chemical production, he says, and unless fused to liquid form it is

impossible to add anything to them.' Fancy calling in the expert for such an opinion on such a question! I give one more example from a weekly journal of high repute and terrible seriousness. This journal gravely discussed a rumour that an American inventor had discovered a compound which possessed the peculiarity of exploding 'forward only.' It was pointed out that if the report were correct the defence of the Northern Frontier of India would be facilitated as it would be possible to substitute parchment for metal in the construction of guns. The subject was referred to again in another article on the 'Air-Cannon'. Nor could the remonstrances of a distinguished friend of mine gain admission to the pages of the journal.

This is rather an old example, but it is so striking that I cannot help recalling it, as an illustration of the kind of thing that is still to be found in high-class journalism.

In case you may think I have been hoarding these examples in a revengeful spirit, I will take events of the present week. Here is a paragraph that appears in Wednesday's paper:

The Discovery of Polonium
Five Thousand Times more Rare than Radium.

Paris, Tuesday.

Madame Curie and M. Debierne, according to a report made to the Académie des Sciences, state that the substance named Polonium has much greater radio active power than radium.

It is five thousand times more rare than the latter, but disintegrated much more rapidly. Thus a particle of polonium, obtained with enormous difficulty, lost half its weight in 140 days, while it takes a thousand years for a similar particle of radium to disappear altogether.

If the transformations which these scientists hope to trace within a year or so are confirmed it will constitute a revolution in chemical science.

What exception is to be taken to this? Well, in the first place Polonium was discovered twelve years ago, and that discounts the headline. The first paragraph announces nothing that was not published in 1906. The same is true of the second

paragraph, except the last part, which is quite wrong. The last paragraph is—well, perhaps it does not matter.¹

Now, when I looked this morning at my paper I felt that there must have been some conspiracy to take away any justification for the remarks I was going to make this evening, for there, in the honourable position of a leading article, was an admirable and interesting discussion of what had actually been discovered about Polonium, and what the paragraph I have just quoted had made such an unsuccessful attempt to announce. The article was evidently written by someone who was well versed in the subject. I say I look upon this phenomenon as the result either of a conspiracy or some strange accident.

I do not wish at all to overstate my case, and I should like to makè full acknowledgement of signs of improvement which are apparent. In recent years *The Times* has begun to publish a weekly Engineering Supplement which is seriously and admirably scientific. The *Manchester Guardian* also has frequent articles on the industrial application of science which are authoritative. The lamented *Tribune* had a weekly scientific causerie written in excellent style by a distinguished physicist. I might give illustrations also from nearer home—as, indeed, I have with some penitence just done. Lately I had a communication from another great London daily foreshadowing a determined attempt to do more justice to science.

Now I am afraid you may think that I am adopting a somewhat censorious and ungracious attitude, and that you are being lectured to, I may say lectured at, more than you bargained for. I will not longer delay giving you my reasons for speaking as I have done. The fact is, my desire that the Press should take a warmer interest in science comes from my sense of the tremendous power for good or ill that rests in the hands of

¹ In the eleven years since this was written there has been little improvement. Equally absurd examples are available from this week's press—January 1921.

journalists. The view that the Press merely reflects public opinion will not bear examination. The journalist knows, of course, that he must give his readers what they want; but he goes far beyond this. He teaches and preaches, and leads and governs—well or ill as the case may be. The newspapers are the literary daily bread, and, indeed, the exclusive literary diet of the great majority of mankind; they furnish directly or indirectly the ideas and aspirations of the community.

I cannot get out of the habit of taking journalism very seriously. I was brought up in the belief that English newspapers were not mainly governed by commercial enterprise and mercenary aims, but that there were high purposes and noble aspirations behind them. They had individuality, character, and reputation. They took themselves seriously, and the public took them seriously. I remember how we despised the typical American paper with its screeching restless sensationalism, its prying vulgar personalities; how we rejoiced when an attempt to carry on a London issue of the *New York Herald* failed.

I am afraid that the Press to-day has not uniformly the character which I have just described, but still there remains a great measure of authority enthroned in the Editorial chairs, and I for one am extremely desirous of enlisting that authority in aid of science.

You will not think, I hope, that if I plead for more attention to science it is for a small or selfish end. It is because I am persuaded of the enormously important part which science has to play in the future of civilization. If we begin with the most obvious material things, it is hardly necessary to point out how much our convenience and comfort depend upon the applications of science. I have at home a spinning-wheel which was used by my grandmother, and a tinder-box which was used by the grandfather of a friend. When I was a student the electric light was occasionally shown as a mere scientific experiment,

and I remember that at one of the first lectures I gave in Leeds, the Chairman said he did not think any man in the room would live to see electricity become a general source of illumination. In those days the majority of people felt no difficulty in believing in spontaneous generation; bacteriology was at its birth, and antiseptic surgery was just beginning to command the attention of the medical profession. We forget, I think, the pace at which we are progressing, and the rapidity with which the applications of science are transforming the conditions of life.

When we come to view the industries of the country we see a like transformation. I cannot attempt to summarize the changes that have taken place, but we all know that to-day the word 'manufacture' is almost a misnomer. Hands, indeed, are still necessary, but it is now the brain that tells. Our industries assume more and more the character of applied sciences, and if they are to be conducted intelligently and to be progressive they must invest liberally in scientific brains. This is a subject on which I have preached in season and out of season, and occasionally I have got into trouble for it. People say it does no good—it merely irritates; they are tired of this everlasting talk about the Germans and their coal-tar colours. Is not the Englishman as good a man as any other? Has he not risen to the summit of industrial and political eminence in spite of his alleged neglect of science? Are there not many other things besides science which are indispensable for success in manufacture—certain deeply ingrained elemental qualities in which the Englishman is supreme? I give a ready affirmative to all these questions, and yet—and yet—I do most firmly and profoundly believe that our greatest material danger lies in the neglect of science in relation to industry. This was eloquently pleaded in a memorable letter by Professor Huxley many years ago. Things have improved since then undoubtedly; but that there is still tremendous leeway to make up I venture to say I am certain. I could enumerate to you, if it were permissible,

personal experiences of my own that are decisive on the point, and if this is so, you can understand how difficult it is for me to avoid calling attention as pointedly and publicly as I can to what I consider to be a grave national danger. You will understand how solicitous I am that the great cohort of public advisors represented by the Press should lose no opportunity of urging upon the community the importance of this question. It is no good doing it upon hearsay; we do not want mere commonplaces such as are the currency of the ordinary speaker at a prize distribution; we want to have incorporated in the Press a sufficient amount of direct first-hand knowledge of these matters, so that real conviction may be heard behind the well-turned phrases, so that the pressure may be incessant and no opportunities lost.

I can imagine someone contesting the assertions I have made. I could myself point to some splendid examples which this country has furnished of the applications of science to industry, of branches of manufacture in which we have nothing to learn, and in which we lead the world. I could give you examples from abroad, where with tremendous scientific paraphernalia they are not doing quite as well as we are here by the use of rather more mother-wit; and I could end up by saying like a true Briton—I am sure amidst applause—that an ounce of practice is worth a ton of theory—a profound truth provided, of course, that the practice is good and the theory bad.

The subject is a complicated and difficult one. It is not, perhaps, as complicated and difficult as the fiscal question. Supposing, however, for the sake of argument, that it is equally important, what are the relative resources of the Press for informing public opinion on the two questions? You know that there is not a single newspaper that could afford to be without expert knowledge on industrial finance. How many are there, I will not say that have access, but who think it important to have access, to expert knowledge on industrial science?

I pass now to another aspect of the subject ; I will leave the material side. That science so largely affects bodily comfort and material prosperity is to many people one of its greatest dangers. I would ask you to consider the effect of science on modes of thought ; I do not mean on opinion—but on the method of forming opinion. I should tire you if I tried to extol science at any length in this respect, for the subject is so well worn. But everyone admits, I think, that science has brought instruments of precision into the domain of thought which can be used more easily and more safely than any other. Science is really an animated logic in which the mind receives its first training among real things—real palpable things—not mere words or abstractions. Now, many years ago you may remember that Matthew Arnold in pronouncing sentence on various European nations condemned the English as being fundamentally deficient in lucidity. Many people thought he justified the charge in making it, for they did not know what he meant—and that, in its turn, justified him. I think it is not difficult to understand what he meant, and I, for one, accept the judgement as just and discerning. On the morrow of a General Election, I do not think it necessary to labour this point. How then are we to cultivate lucidity? Doubtless there are many ways of doing it, but if it involves an improvement in our methods of getting to the bottom of things, of collecting and weighing evidence, of organizing our facts, and of generalizing them to a clear conclusion, I cannot see a more hopeful expedient than to bring to bear the methods that have been so wonderfully successful in the realms of science. I am not going to talk politics, as you can well understand, but I ask you to consider the Fiscal question from this point of view. Just think of the method taken by the country to decide this question ; think of the kind of appeal to the intelligence that has been made ; think of the competence of the average elector to weigh up the pros and cons of a question of such complexity.

And yet how far have we heard from our guides, philosophers and friends any sustained advocacy of a better course? Are we to conclude that this country is so inextricably bound in the ties of partisanship that it is hopeless to constitute from its leading men, a court willing and competent to make an impartial inquiry, to collect and weigh evidence on a complex question of vital national importance, and to declare an opinion conceived in the interests of the nation as a whole?

You will ask what can science do here? I do not give a direct answer. I can only say that the more familiarity we have as a nation with the methods of science, the more we shall distrust mob-law, the more we shall learn that the prejudices, the jealousies, the vested interests, the intolerance which inevitably arise when well-meaning men segregate themselves into parties, sects, and schools of thought, are fetters on the mind and spirit, and an incalculable hindrance to human progress. A vicious loyalty is created which makes men aggressive and vindictive towards those who consort in a different school of thought; which makes them palter with the truth and finds them in extremity driven to the expedient, now so evident in the world, of maintaining that white is only a lighter, and black a darker, shade of grey.

I commend to you most earnestly, I hope not arrogantly, the task of doing more than you have yet done to educate the people in the knowledge, the love, and the right use of science. The century that has not long closed has brought to mankind intellectual weapons mightier even than those forged in the days of ancient Greece, and we are, consciously or not, on the wave of an intellectual movement of overwhelming force.

Science is one of the things in this world that must continue to grow in power and influence. Its march is irresistible and endless, a progress from which there can be no retreat. The hypotheses of science vary from day to day; the fabric

grows steadily. It is there; you can see it. That I conceive to be the ultimate value of its material side; it proves that your progress is real. Science is not a philosophical or metaphysical *system*, a scheme of thought, which may be overcome by a greater scheme of thought to be developed in the future. It may look like it. You may hear men discussing, like the schoolmen of the Middle Ages, how many fairy electrons can dance on the point of a needle; but there issues from the discussion not a nightmare literature to hold men's minds in bondage and mystification, but something like wireless telegraphy to relieve an anxious heart that is yearning for the safety of a friend in peril a thousand miles away. Science is a revelation, a revelation that will stand the test of time. Poets may sing, and eternal truth may be in their song. The great races of the world may each have their own prophet, and what they have said about what was and what is to be may have eternal truth in it. You may believe one or you may believe the other. It depends, I suppose, on where you were born, or on the measure of authority some human being has exercised upon you, or the extent to which your hope or fear allows you to be swayed by some enchanting vision. Science does not enter here. It pretends to no final knowledge of the ultimate or the infinite. It has gone after all but a little way yet into the mysteries of great Nature. What it has revealed is there for all the races and generations of mankind to see and acknowledge, and for none to deny, unless forsooth, in the strange wanderings of the human spirit, it pleases them to deny everything outside that spirit. So much as is revealed we may believe. How much we may hope is at our option—an indulgence that few will resist in its clamorous onset. Yet there is something stronger still that can come, and should come to give peace to our spirit—reverence and humility, as we gaze upon the little fragments of truth that our Titanic efforts have quarried from the illimitable store.

It is because I see in science the surest and most permanent springs of reverence that I care to fight for it, that I grow vehement in its defence, urgent with its claims. I am outraged when I hear it subject to the flippant jests of some self-styled humanists—half-educated men I should rather call them, who stand deaf amid the deepest harmonies of nature.

I deplore, like other men, and more than most, the mud of materialism that fringes the path of science. I do not know that a bigoted man of science is more harmful than any other kind of bigot, but he is sufficiently unedifying, and I will gladly join in suppressing him. But that the essential tendency of science is materialistic I would deny with my last breath, and if there is anything unprovable about which I feel confident, it is that science is destined to provide humanity with the abiding reverence, the love of truth, the freedom and sanity of mind and spirit, without which religion and morals are but names and life is not worth living.

*The University and Women's Work*¹

THE movement which we inaugurate to-day embodies one more attempt to knit university studies to the common occupations of life and to break down the barriers which custom has set up between thought and action. This is a cause which I serve with my whole heart, for nothing has seemed to me more necessary in the interest both of education and of right-living.

I think that no one who surveys the educational history of this country can fail to see that there is a tendency for the world of learning and the world of action to drift apart, until they seem to be almost in opposition. The earlier part of my life was spent largely in the atmosphere of what is conventionally called business, and I am certain there prevailed a general feeling among business men, that not only a little but also a good deal of learning was a dangerous thing. Such aphorisms as 'an ounce of practice is worth a ton of theory' are characteristic of that feeling. Later on I became more immersed in the world of learning, and encountered men whose habitual attitude towards business was one of intellectual disdain.

I believe that the explanation of this state of things is to be found in the fact that the educational system of this country has been for so long conceived exclusively from the point of view of the learned professions. We must remember

¹ Address delivered at the Inauguration of the King's College (London University) courses for the Higher Education of Women in Home Science and Household Economics, October 2, 1908.

how sharp the distinction once was between these professions and other callings in life, and how little there was in the practical arts that exacted anything in the way of formal education beyond that general training of the intelligence, which improves the mental powers without in any way specializing knowledge. Special training for the practical arts, so long as they were nothing but crafts, lay only in practising them under a good master; apprenticeship was the real preparatory school. An extended school or college education did not seem to be very much to the point. It seemed to involve the risk of detaching a man from the currents of active life and making him into a kind of superior person endowed with a large fund of unnegotiable paper knowledge. It involved, also, a sacrifice of those early years of practical training which some people consider indispensable for the inculcation of good craftsmanship.

It is surely to be deplored that the educational institutions and systems of this country have been so much designed for the interest of one set of callings, and that they have been so slowly adapted to changing needs.

It is not uncommon to find people talking of universities as pre-eminently places for general education. No doubt they are so in a broad sense, that is to say, so far as general culture of the mind, the training of character, the development of individuality, and the acquisition of the graces are concerned. But surely it is also the case that the older universities were and still are, to a very large degree, schools of specialized professional knowledge. Oxford and Cambridge have been training schools for ministers of religion, for lawyers, doctors, schoolmasters, statesmen, men of letters, and men of science, and this fact has had the most important consequences. The preparatory education suitable for these special studies became stereotyped as the one and only kind of preparatory education for mankind in general, and it was established, in various

degrees of dilution, for all classes of the community throughout the length and breadth of the land. I have heard it alleged that this dominance of what are called classical studies is quite as much due to the former practical necessity of learning Latin, because it was the common tongue of the learned professions, as to the intrinsic merits of the language and of the humanizing literature that it enshrines.

The fact that the education of this country has been so long dominated by the interests of the learned professions, seems to me to account for a good deal, and, amongst other things, for the want of sympathy with education which has characterized the average Englishman outside the professions in question. Attempts to add to education or to alter it in the interest of those who are engaged in other occupations have been made mainly outside the old universities, and have produced a new educational movement which, instead of being merely supplementary to the ancient order of things, has come to be at some points in antagonism to it, and given rise to mischievous attempts to set one kind of learning above another.

The fact is, that the great change which took place in the conditions under which the practical arts are or may be pursued was not accompanied by simultaneous changes in the world of education. The change that I allude to is this, that whilst at the beginning of the nineteenth century the practical arts were little more than crafts, at the beginning of the twentieth century we find that they have an intellectual basis. The laws of nature are not new, and industry has always had to conform to them, but the revelation of these laws, their bearing upon industrial operations, their intimate relation to success and failure—these are matters of new knowledge, and result from the marvellous intellectual achievements of that century which posterity will surely know as the golden age of science.

In my dictionary I find a profession defined as 'a calling

superior to a mere trade or handicraft'. Note the word *superior*. Superior in what respect? I do not know—I cannot imagine in what respect, for example, is the work of a trained surgeon to-day superior to that of a trained agriculturist. Certainly it is not intellectually superior. A good farmer of the old-fashioned kind may remain what he was—a man who, by virtue of other things than scientific knowledge, can successfully till the soil, rear good live stock and turn out good produce; but we know that real improvement and progress rest with the trained agriculturist, with whom farming is a science as well as an art—a man who is working in obedience to principles rather than precepts, and has the light of connected scientific knowledge to guide his hands, to interpret his own and other people's experience and to give him new ideas.

And so with a host of other practical arts. They have their technologies; they are linked to high learning; they engage the mind as deeply and as worthily as any learned profession.

These things are being recognized, and special training is now being provided, especially in our newer universities, for many industrial callings. We are also seriously asking ourselves whether the type of general education, which has so long prevailed in our schools, is not capable of some readjustment which will make it better subserve the life interests of the average man and woman. The importance of such an element as manual training is being successfully urged, and, indeed, there is at the present time, amidst the clamour of religious controversy, a peaceful revolution taking place in our methods of education.

None of us, I suppose, would wish to forget that education should concern itself primarily with man as a human being, but I confess I become impatient when I find people exalting this ideal to the exclusion of all others, and I have a particular grudge against those people who will approve special education

for the learned professions but take alarm whenever any other kind of special education is mentioned. People who look with complacency on the association of a hospital with a university for the benefit of students of medicine are sometimes scandalized by the suggestion of a university farm or anything in the nature of a workshop.

I have made these remarks for two reasons. In the first place, I wanted to explain and to discount a kind of criticism to which we are sure to be subjected because we are doing something new in the way of special education. In the second place, I wanted to emphasize the fact that at the present day we have for men, as distinguished from women, university training for a great variety of professions and industrial callings.

Let us now ask how matters stand in the case of women. What are the university privileges of women? They are practically these, that so long as women are willing to restrict themselves to the same callings as men, they have pretty nearly equal educational opportunities; but so far as women's special callings are concerned I am aware of no special university courses anywhere in this country.

The question then arises, are there in fact any such special callings to which university education may be particularly directed? My own reply to this question is a most emphatic yes. The most usual calling of women, the making and administering of a home, is surely one to which a university may fitly contribute special knowledge.

We must not assume that this view will be universally admitted. On the contrary, it has been maintained with great vigour and persuasiveness that there is no place at all for any such special studies as I have implied. With respect to all matters of the home we are told that what is wanted is that women should bring their intelligence and common sense to bear upon it, that it is nothing very mysterious, nothing that

an intelligent woman whose mind has been trained, whose habits of observation have been called out, cannot learn very quickly if she desires. A really well-educated woman, it is said, will know what she wants to learn and how to learn it. 'The time for learning it is when she needs it. What she needs is a trained intelligence, a wide outlook, real interests in life.'

I am very familiar with arguments of this kind ; they have confronted every attempt to create special studies. They do not impress me, but they are difficult to reply to because one can hardly do so without suggesting that the people who urge them are deficient precisely in the kind of knowledge they deprecate. I have been told again and again by men engaged in chemical industry that chemistry was of no use to them, and they have maintained this while their fortunes were being ruined for lack of what a knowledge of that very science would supply.

I admit that it is very important for all of us who are advocating special educational schemes not to forget how much the trained and flexible mind, the wide intellectual horizon, the aesthetic perception of the fitness of things, the sense of proportion, all secured it may be by the most remote studies, promote efficiency when mind confronts action. Let us remember also how much there is of a man's and a woman's best powers that comes from influences outside all formal educational systems. Men and women have talents and aptitudes of all kinds. These are developed in the school of experience and may become really great powers which determine success. A good business man, a born housewife—these are well-recognized types, but who will venture upon an analysis of their qualities? We must never underrate the value and power of native talent and of experience. I know a man whose great worldly success is attributed to his power of judging a piece of leather by its feel, and you will find some Sheffield workmen who can detect by eye the difference

between one piece of steel and another when the difference in the proportion of carbon is only a tenth of one per cent. Whatever we do we must not belittle these things; they are vastly important, and it is the theorist's tendency to overlook them that so exasperates those who know their real value.

All the same, do not let us be deterred from enlisting all the intellectual aid we can secure in furthering all good human pursuits, however much they may seem to depend for success on experience or talent. An educational institution is intended to economize experience and to develop talent. It is a repository where accumulated experience is organized and distributed as knowledge, and where the means of acquiring experience in the most intelligent and effective way should be imparted. The statement I have quoted, that a well-educated woman will know what she wants to learn about the household and how to learn it, and that the time for learning it will be when she really needs it, seems to be a negation of all educational enterprise. Is there, or is there not, a body of special knowledge lying near the work of a woman who has to administer a home? Is the position of such a person at all comparable with that of an agriculturist or an engineer? If it is, then the province of knowledge in question is surely worth cultivating. I have not a moment's hesitation in answering these questions in the affirmative. There is undoubtedly a vast body of special knowledge lying in the closest relationship to the administration of a home. This knowledge is of a very varied kind. It may relate to the humbler household arts such as those of the kitchen or laundry; it may concern the more distinguished subjects of hygiene or economics; or it may range into the still sublimer regions of psychology and ethics.

The short syllabus of the new courses which are being established in the Women's Department of King's College discloses, I think, an ample field of special knowledge which it

will tax the resources of any university student to exhaust. Applied chemistry, sanitary science and applied hygiene, bacteriology, general biology, physics—these sciences of course accompanied by practical work; economics of the household, general and child psychology, ethics; practical work and demonstrations in the actual household arts—here is a syllabus which in the hands of skilled teachers will provide an education which may be fairly placed on the same plane as the special education proper to any learned profession. It is not a question of whether we can get along without this knowledge or of imposing a formidable curriculum on all who aspire to manage a home. The question is this—is there not here a store of knowledge lying pent-up which ought to flow into the human calling to which it relates, knowledge which is certain to improve, enlighten, and elevate that calling and to contribute to human well-being? If so, it is surely worthy work for a university to disseminate this knowledge as best it can.

The possibility and advisability of organized instruction in reference to some sections of home life have long been recognized, and for many years we have had schools of domestic economy where the household arts have been taught by those who are specially skilled in them. It is admitted that among the poorer classes of the community the condition of things is such that passable competence in even the most primitive domestic arts—such as cooking, washing, and sewing—is not secured if things are left to take care of themselves. The crudest facts of hygiene, the importance of cleanliness and fresh air, the simplest means of protection against disease are not learned or respected. It would be possible and legitimate to paint an appalling picture of the misery and suffering which exist in the homes of quite respectable poor people simply and solely because of their ignorance. The facts have forced themselves irresistibly on public attention, and the State has found itself compelled to give more and more time and money

towards supplying in schools some rudimentary knowledge of the domestic arts and the simple laws of hygiene. No one, I think, will contend that a solution of the difficulty is to be found here in general education in the three R's, and it is in supplying special teachers for children in elementary schools that schools of domestic economy have found their chief work.

When we pass from the poorer classes to the more fortunate sections of the community it is not so easy to disclose the ignorance that prevails or trace its consequences. Of its existence and of its far-reaching effect on the well-being of the nation I have not a shadow of doubt. The subject is not an easy or a pleasant one to talk about, and it will probably be most prudent if I do not enlarge upon it. I can only say that it astonishes me more and more as my experience of life increases, to see how complacently people endure in their homes the inconveniences, the perils, and even the tragedies of life that accrue not from faults of the heart, but from crass ignorance—ignorance that would have been remedied long ago if we had not got our ideas of education so absurdly out of focus with the things that matter most. It is, I am sure, not extravagant to say that there is no sphere of human activity where the responsibilities are greater, the issues more vital, and where, accordingly, we are more bound to bring all the resources that intellect can supply. By so doing we may hope to strengthen the power of right thinking and right doing, to emancipate people from the rule of thumb and of recipe, the spurious traditions and the mischievous credulity, that have gained such an extraordinary sway in the domestic world, and to bring about an economy of life, labour, time, and money.

I believe there was never more need than now for most earnest attention being given to this business of administering a home and of making it one that may appeal to the intellect as well as the heart. A highly educated woman surely need

not mean only one who has gone far in some abstract or professional study. Can she not become highly educated as a home-maker, in the same sense as a man may be educated for engineering ; that is to say, thoroughly equipped with the branches of special knowledge related to the calling ? I believe without doubt she can, and I feel confident that when the way is open we shall find plenty of young women of talent who have the inclination and the opportunity to devote a few years to this kind of higher education, and who will return from it ready to enter with redoubled interest and usefulness into the realm of home life, or to take up one of the many posts in civic or social work for which the same type of training is so desirable.

I have already alluded to the existing schools of domestic economy. These schools have long been doing a most valuable work, and I particularly desire that we should recognize and acknowledge their services as fully as they deserve. They have in many cases been established by the arduous and self-sacrificing labours of women zealous for the public interest ; in others they have formed a section of the work of polytechnics and kindred institutions. For many years past I have had a semi-official connexion with one of the best of them, and it is through this that I have become impressed with the great importance of the work they have in hand and with the difficulties they have to face. The first demand made of these schools is that they should turn out pupils skilled in the practice of the domestic arts. This, of course, is reasonable enough, but it has made it very difficult for those in charge to include as much of the theoretical or scientific element of the subjects as they would have wished, and the consequence is that they have recruited their pupils largely from the ranks of those whose tastes and talents are of a practical kind. It has long been my desire to see a somewhat different type of training attempted, for ever since I took an interest in these

schools I have been more and more impressed with the magnitude and importance of the more theoretical side of household administration, and especially with the undeveloped and unorganized state of the science that relates to it. It has, I confess, been a revelation to me to find how much there is in this direction that lies outside the interest or cognizance of the orthodox professor or teacher of science, how many unsolved problems there are relating to the most common things and operations of the household, and what a field lies open for interesting and exacting research. I am speaking only of the sciences with which I am most familiar, but if it is true that there is a special province of physics and chemistry associated with these matters, it is, I believe, not less true that there are special provinces in other branches of knowledge.

A curriculum which shall include a more thorough study of these special subjects must necessarily differ in aim and character from those which have usually been given in the schools of domestic economy. Inasmuch as it is more theoretical it will be necessary to exact a higher standard of preliminary education, to extend the time of the course and to distribute the theoretical work among the best special teachers that can be secured. The work will indeed not be satisfactory unless it is centred in institutions where it will have the aid of many contributory studies, and where it will lead to the prosecution of vivifying research. So far as the practical side of the household arts is concerned, some sacrifice must be made. The project is surely such as may well come within the province of a university. It certainly demands the highest intellectual resources that we can obtain; it is in no degree inferior in substance or in aim to any other university work.

The pupils we turn out will, I am confident, find abundant opportunity for the use of their knowledge. There is use for it—ample use for it—as I have said, in the privacy of home

life; there is use for it in the management and administration of public charities and other institutions and occupations relating especially to women and children, and there is use for it in the teaching world. In this connexion I should like to draw attention to the very interesting changes and developments that are taking place in girls' secondary schools. On every side these schools are providing special courses of work relating to household affairs, usually following, but sometimes accompanying, the ordinary school course; and there is, I am happy to say, an ever-increasing desire to make the science teaching in girls' schools bear more particularly on the things and phenomena of the household. From my own observations, and from the letters that I am continually receiving, I am sure there is a real dearth of teachers who have reasonable familiarity with that borderland knowledge which lies between the formal sciences and the practical arts of the household—just that part of knowledge in fact which we include in our new scheme. I do not doubt therefore that many of our pupils will become teachers of a true domestic science, that they will co-operate in an effective way with the teachers of the domestic arts, and that they will help to raise the position of these home training classes in secondary schools, so that they may not be regarded as a sort of despised feminine modern-side, destined primarily for those who are deficient in brains or industry.

The establishment of courses of instruction in home science and household economics in connexion with universities is no new thing. America has not failed to include this among its abundant educational enterprises, and in far Japan we have a women's university which I believe, from all I have read and learned, might teach us many a useful lesson. We shall do well to study what has been done elsewhere, but I am not desirous that we should merely imitate. Transplanted schemes often perish like exotics, and it is better for us to let our schemes

grow under our own special conditions and in conformity with the national genius. We shall doubtless make mistakes and succeed only after patiently groping our way. My chief hope lies, of course, in a strong conviction of the need of our work, and of its beneficent results on the national life, but in addition to this I may be permitted to say how much my confidence is strengthened by a knowledge of the auspices under which the work is started.

Our pecuniary resources and our equipment are not all we could desire, but we must be grateful for enough to start upon. I am sure that this is an enterprise which, if successful, will bring the sympathy and support requisite for its maintenance and expansion, and it is in many ways a less anxious business for those in charge of the work to begin in a modest way than under conditions which create a restless demand for proofs of success.

I can only say once more I have the fullest confidence that the work to which we are setting our hands is good work that is greatly needed, and that it is work eminently worthy of the brains of a university. If we succeed here, as I have not a doubt we shall, other universities are sure to follow our example, and so it is my fervent hope that we shall see before long a widely disseminated higher education of women which does not carry with it, what has always been to me the melancholy suggestion of women drifting away from the grandest of all their vocations—the making and minding of a home.

Note.—The Household and Social Science Department of King's College for Women is now (1921) housed on a site of two and a half acres on Campden Hill in beautiful buildings including Queen Mary's Hostel. About 200 students are in attendance, and the London University has recognized the special studies in its B.Sc. degree.

*The Place of Science in Indian National Life*¹

FOR five months it has been my privilege to reside in the Punjab, and there to do the little that lay in my power to assist the cause of scientific education. I shall not forget, in speaking to you this afternoon, that my experience in India has been limited both as to time and as to place, and I shall try and be on my guard against those hasty generalizations to which one is prone under such conditions as I have described. I find, when I talk with my countrymen in India, that their readiness to dogmatize about the country is pretty well inversely proportional to the time they have spent in it, and the men who have been in it for a long time seem to have given up all idea of making definite affirmations as to what is right and what is best in connexion with the complicated problem of the welfare of India. I should like, however, just to say this much for myself, that although it is true I have spent only five months in India, I have been for a long time interested in the scientific work that is in progress here. It has been my good fortune in England to have a considerable number of Indian students in the university with which I am connected, and in addition to see a good deal of students taking up the study of science and technology in the other centres in the United Kingdom.

Now I want this afternoon to tell you very briefly some of the impressions that I have formed and to indicate to you, necessarily also briefly, what I think the position of science

¹ Address at Bombay University, delivered March 1914 (reported).

should be in the life of a country such as this. I have found in the province where I spent my time in the first instance a widespread belief that science is a good thing. I have found a great deal of teaching in schools and colleges and increasing tendency to supply such teaching. I know of very notable instances in India of great endowments given to the cause of science, such as the well-known establishment, originally due to the Tata family, in Bangalore, and a similar endowment in Calcutta; while in Bombay itself there are also striking examples of the generosity of the private citizen as well as of the Government. I have also found in the Punjab a certain amount of research work of a scientific kind in progress by Englishmen and very little indeed by Indians. Then I have also found some very imposing examples of the application of science to public health and agriculture, not only in the Punjab but all over India.

In addition to these things, if I am to be perfectly frank, I must acknowledge to have observed what I consider to be a good deal of wrong thinking or wrong doing, or not doing at all, that might be rectified by the proper application of science. And lastly, I found here, as I am bound to admit I have found in the West, a very widespread ignorance of what science is and what science can do.

Now the aims, the methods, the achievements, the functions, and the possibilities of science have been often stated. Throughout the nineteenth century, science—by science I mean natural science—was really emerging and fighting for its existence; and incidentally to that fight its claims were frequently stated—stated with far greater force and eloquence than I can hope to command, stated not infrequently in a tone of considerable aggressiveness. If you wish to read of what science may be in relation to education you will find no more eloquent, no more complete, I will not say no more perfect, but at any rate no more striking a plea than

is contained in Herbert Spencer's well-known book on 'Education', and if you wish to know what science has done and what it may be, how it stands in relation to things intellectual, to things moral, to what in brief we may call culture, you will naturally betake yourself to the writings of Huxley. Other names might be mentioned; Tyndall, the friend and colleague of Huxley, was a champion in the fight for science, and many minor names may be added to these major ones.

The fruits of this campaign are abundantly evident to-day. Science in many respects has won its place and acquired its workers. We find ourselves continually being enriched by the fruits of scientific discovery applied to the practical conveniences of life. We expect regularly gifts from science such as those which produce wireless telegraphy, X-rays, radium, and so forth. And again, we can see the fruits of the campaign to which I have alluded in the change of thought both in philosophy and in theology. And thirdly, we can see the fruits of the scientific campaign in the evolution of educational institutions, among which I would quote the example already cited by our Chairman, the establishment of what are called the modern universities in the various industrial centres of England. Notwithstanding all this potent evidence, I believe the cause of science needs continual restating, because no one who looks into the circumstances can fail to admit that science teaching as an element of general education is still very greatly neglected, and because amidst the clamour for the introduction of science, and amidst the multitude of counsellors, there is a considerable amount of confusion, and the public gains a wrong notion as to the incidence of science both in education and in the life of the nation. Further than this, it is being stated to-day that the claims which were so enthusiastically put forward for science in the nineteenth century have not been substantiated; that science arrogated to herself at that time the power to explain

everything to the world; and that now she finds that she made a mistake. The claims staked out, it is stated, were extravagant and untenable.

When I was at Lahore and have been asked to address popular audiences on scientific subjects I have not tried to give what is called a popular lecture on science, for the simple reason that I did not think that I would find an audience that would take a popular lecture on science in a way I wished it to be taken. I was confident that the great bulk of the audience would have to be instructed in the very elements of science, and to attempt this and, at the same time, to give an account of the recent development of science in the space of a single hour is perfectly futile. A popular lecture on science is, therefore, very apt to reduce into a mere tickling of the imagination and a display of imposing experiments; and to that I declined to stoop. What I have done when I have spoken in India has been to try and illustrate what science really is, by giving some account of the life of a scientific man, and the particular man that I have selected has been the great Frenchman—Pasteur.

In the first place, he was one of the greatest scientific men who ever lived. In the second place, he was the man whose scientific work told in an almost unparalleled degree and with unparalleled rapidity upon the welfare of the human race. In the third place, the work of Pasteur was devoted to fields which are very much the same as those that above all others await cultivation in India; I mean the fields of agriculture and public health. And in the fourth place, the life of Pasteur illustrates not merely the potency of science as an instrument for the amelioration of the lot of humanity, but shows what science at its best really is, not only intellectually but philosophically and morally. May I remind you now very briefly of the achievements of this wonderful man?

He was born in the year 1822, and after his school days,

which were undistinguished, he resolved to become a teacher. He then entered the training college at Paris and there manifested his first real interest in science. The subject which secured his interest was one that promised no practical fruit whatever. It was a peculiarity regarding a particular crystalline substance, viz. tartaric acid. By a scientific anomaly relating to this substance Pasteur's curiosity was excited, and he made up his mind to explain the anomaly. In that way he first acquired his training as a scientific investigator in what may be called pure research. In time he obtained his post as a teacher, moving from one place to another until he settled down in the industrial centre of Lille, where he was very soon called upon to give his scientific assistance in connexion with an important industry. The industry which he was called to assist was the manufacturing of alcohol from beetroot sugar. This is conducted by a process of fermentation. A large manufacturer, whose son attended Pasteur's class, found that fermentation had a way of going wrong and producing an alcohol which was unfit for sale. Pasteur was appealed to. He took up readily the examination of the difficulty and he very soon found what was at its root. He gave his prescriptions. These prescriptions being followed, all difficulty disappeared, and in that way Pasteur had his interest aroused in the phenomena of fermentation. The phenomenon of fermentation up to that time was almost completely unexplored. It was after the birth of Pasteur that it was first recognized that the organism which produced fermentation was really an organism at all. It was realized, about 1836, that the yeast which was always found in fermenting liquor was really a living organism, which, if observed under the microscope, was found to grow. What was its relation to the process of fermentation no one knew. All that was supposed was based on little more than speculation. Pasteur resolved to take up this inquiry and

very soon satisfied himself that the process of fermentation was connected in some way with the life and growth of yeast plant. And when he had established that, he had to decide the question as to the access of the yeast to the liquor which underwent fermentation. In many cases it was deliberately added. In some cases it was not added. In order to make wine, all that is necessary is to take the grape, crush it, and then the liquor undergoes fermentation and alcohol is produced. Whence comes yeast, no one knew. It was thought it came from nowhere in particular. But Pasteur, early in his career, formed a strong prejudice against the view that living things can come into existence without parentage, and he expected, that wherever fermentation occurred the yeast somehow must have come in from outside. The process of fermentation is akin to putrefaction and the connexion between the two was easily discerned by Pasteur. In liquids undergoing putrefaction Pasteur found organisms not unlike those which occurred in fermenting liquor, and studying the process he came to the conclusion that putrefaction, like fermentation, depended upon the access to the liquids of organisms from an outside source. The only other explanation was that the organisms were generated in the liquid within which life did not previously exist. So Pasteur was led to take up the question whether life ever came into existence in the world without parentage, a view which nowadays may seem remarkable and utterly unacceptable, but which in those days, not very remote—I am speaking of a time well within my own memory—seemed to be almost a matter of course and a matter of no surprise. Then Pasteur began to try and find out whether the germs that cause fermentation and putrefaction came, as he supposed, from outside. And he found that the germs did come from outside, and so he founded the science of bacteriology. He showed that if means were taken to use materials which in

the first instance contained nothing living, and to shield from the liquids which are placed in the vessels that are used the access of all germs from outside—under those conditions neither fermentation, nor putrefaction, nor any change of that kind ever took place. Then Pasteur thought that disease, like putrefaction and fermentation, was probably the work of organisms which had access to the human body. And he began to realize his desire to investigate disease. The first disease that he took up was one that afflicted sheep, known as anthrax or charbon, and also as wool-sorter's disease because it is one which can be communicated to humanity. He very soon found that a new organism was evident in the blood of infected animals which was not in healthy blood, and by taking blood from these infected animals and inoculating healthy animals with it he was very soon able to prove beyond all doubt that the transmission of the disease from one animal to another depended upon the communication of the germ.

The next disease was one affecting fowls, and he found the same thing: that in chicken cholera the disease was accompanied always by the presence in the blood of a germ, which was the means of transmitting the disease to another animal. Then he found out, by what many people would call mere accident—the accident that only men of genius can use—something very much more important, viz. that if you kept the active germ it lost virulence and after a certain number of days, if introduced into healthy animals, would produce the disease in a mild form. And he found that when an organism of that kind, one whose potency had been weakened, was injected into the healthy animal not only did the animal have a mild attack, but it became immune to the influence of the active organism. He discovered, in fact, the principle of treatment now so well known and so widely practised, that of preventive inoculation or vaccination,

a method which had been used in connexion with small-pox, but which now was made available for another serious trouble affecting the animal kingdom. These discoveries of Pasteur's, demonstrated as they were by the most carefully collected evidence, did not convince the medical people of his own country. There is deep conservatism in almost all minds and especially in certain intellectual minds, and this conservatism was extremely evident in the medical profession of France. Pasteur's theories were doubted. His experimental results were questioned, and eventually in order to put matters to test a great public trial was arranged and carried out in regard to the disease anthrax, that I have already spoken of as affecting the sheep. This particular trial marks one of the most important epochs in the history of medicine. Sixty sheep were placed at the disposal of Pasteur for trial. Ten of these were put aside and nothing was done to them. Of the remaining fifty, twenty-five were treated with the preventive inoculation; twenty-five were not so treated. Then the whole fifty, inoculated and non-inoculated, were given a dose of active disease germ. Time was allowed to lapse, and then, spectators having gathered from all parts of France, the herds of sheep were examined, and when the appointed day had expired the twenty-five inoculated were in excellent health and the twenty-five non-inoculated were all dead. I cannot go on giving a complete story of Pasteur's life. I merely wish to give an idea of the method by which he was led to attack and solve the problems that lay in front of him in relation to the great pressing needs of humanity in France. These investigations were interrupted for a period by Pasteur's being called away to render service in combating another disease affecting silkworms which was threatening to ruin one of the greatest industries of France. The silk industry of France is worth many millions. It was threatened by a peculiar disease which

affected the whole of Europe, a disease which rendered the silkworm useless for the manufacture of the silk. In one district of France alone over eight million pounds had been lost in fifteen years owing to the ravages of this disease. Pasteur was called in, and although he knew nothing of the industry or the silkworm, and was never engaged in any silk business, yet by the application of his methods he got to the bottom of the trouble and gave a prescription for the remedy. The particular achievement with which Pasteur's name is most associated was the last and in many respects the greatest of his life, that in respect to the treatment of hydrophobia. You happily possess two Pasteur Institutes where anti-rabic treatment can be given and people can be spared from the awful consequences that are too likely to ensue from the bite of a mad dog. I have no time to tell you the stages by which Pasteur achieved this great discovery but I think you will gather from this brief indication of Pasteur's work that you cannot find a better example of the cultivation of science for the welfare of a nation.

You may say that this is a material view of science. It is no doubt in a sense a material view. But it is a view of science that surely no benevolent person would in any way ignore or belittle. Health, after all, is the first consideration. If you have not got health you cannot have a nation at all, and the direction of science to the subject of public health seems to me to be one of the first calls to which a scientific man should respond. It is possible also to be too censorious about the utilitarian application of science in relation to the practical arts. We are often told truly enough that man cannot live by bread alone. At the same time man must have bread among other things. And a man who, like Pasteur, could rescue a people from industrial destruction is surely rendering a magnificent service to the nation to which he belongs.

If you want to see science on its more purely material side you can take the German nation. I should like to tell you about the development of science in Germany. You know, no doubt, that at the present time there is no nation in the world which has developed science so thoroughly, which has applied it so closely to national life as Germany. And this has been a very rapid achievement. At the beginning of the nineteenth century Germany was not in any way conspicuous in science. The development took place after the first quarter of the nineteenth century had passed. But since that time it has developed with marvellous rapidity and has produced material results in Germany of the most imposing character. It is really remarkable to read things that were written of Germany so late as 1840. The great Liebig, the person much more than any other who is responsible for giving impulse to the teaching of science, in that year published a paper in which he speaks in the most deploring terms of the position of his own science in Prussia. He says that in that time there was not a single teaching laboratory. The whole enthusiasm of the learning world was for literary and classical studies. He commended science not only for its own sake but for the profits which certainly came through it to national life, and he remarked that 'in fifty years the neglect of science would be looked back upon with incredulity and a smile of pity'. Considering that condition of things it is nothing less than marvellous to regard the condition of German science to-day. If we take the whole range of science, physical and biological, I think it can be affirmed that there is no country in the world where there is so much activity, so many workers, so much State endowment, and so great an output of publication. It is, I should like to say, the great number of scientific men that is the noteworthy feature. I do not say for a moment that they are greater scientific men than those of other countries.

The result has been the creation in Germany of a material prosperity which is quite extraordinary. The example that is often quoted is that of the German chemical industry. That industry, developed within a period of half a century, produces a yield of something like fifty million pounds sterling annually. To take one single thing and a striking example of what Germany has done in science—in 1897 Germany imported natural indigo of the value of six hundred thousand pounds, and in 1912 she exported artificial indigo of the value of over two millions, and a good deal of it to India! In Germany there are at the present time probably no less than twenty thousand people being trained in science in the institutions of university rank as against 2,600 in England; so that whilst the population proportion of the two nations, Germany and England, is 13 to 9, in the highest education the ratios are 13 to $1\frac{1}{2}$. There are over 4,000 highly trained chemists employed in German industries.

Now I have told you perhaps enough about France and about Germany. I must get back to my main theme. It is obvious from the examples I have chosen that the highest science such as that of Pasteur and that of Germany 'pays'. It effects great improvement on things that exist, and from what exists develops great things that are new. I lay stress on this last qualification for a particular reason. There is a belief which is widespread, and to which utterance is sometimes given, that research pure and simple is calculated to produce very great material results. I have read since I came to India, in the *Hindustan Review*, an article on 'Scientific Research in India', which had many merits. But so far as I could read, the paper seems to be fraught with one most serious mistake. The author in one place says, after alluding to one of the greatest workers of the past, 'What urged the scientists to these battles and these victories over nature which have become [the heritage of the human

race? No one of those great investigators from Aristotle to J. J. Thomson, according to the ordinary definition of the word, had any "practical" end in view.' Surely there lies a great misapprehension and a great misstatement there. My reading of scientific history tells me, I won't say exactly the reverse, because there are countless cases of most important scientific work having originated in a simple desire for truth and nothing more. At the same time, if you really look into the history of science you will find that there is a very large proportion of the highest, the most important, the most theoretical science, that has arisen from the effort of science to solve practical problems. Take my own science. Who is the greatest man in chemistry? I think, with all due regard to patriotism, and with the strongest desire to be fair, one would be obliged to say Lavoisier, whose work revolutionized chemistry. What was the beginning of Lavoisier's work? If you inquire you will find it was the desire to improve the illumination of the streets of Paris. The streets were badly lighted and a prize was offered for improvements. He addressed himself, first of all to the construction of the lamps, to the minute construction of the burners, and matters of a mechanical kind. Then he came to think about the question of oil. From that he found the necessity of understanding the process of combustion, and because oils and other fuels were too complex material for investigating the simplest aspect of combustion, he passed to the investigation of the effect of fire upon metals. There he made his immortal discoveries and revolutionized chemical science. Throughout his life he was eager to solve the practical problems which he found in his own environment. I can give you innumerable examples of the same kind.

Whilst, therefore, I should be among the last persons, I hope, to say a word against dispassionate, disinterested cultivation of knowledge for its own sake; while I should be

among the first to admire the men who have pursued truth as the hermit pursues piety, I say it should not be forgotten that science applied to the practical problems that call for solution yields an abundant fruit of pure truth. And I go further than that and I say, speaking of a country like this, that the first claim on high science is for research directed to real and urgent national problems. When I landed in this country and took the long journey from Bombay to Lahore, two things were constantly coming to my mind—I am now speaking as a chemist—agriculture and public health. Are not those the two great scientific interests of this country? When you think of the death-rate and the scourges to which the land is subjected, when you think that they are largely preventable, you will surely admit that the first claim upon science is that it should be directed to the amelioration of such things as these. When you realize that in India nine out of ten are engaged in agriculture, when you see how much of the agriculture of this country is primitive, then surely also one of the first claims made upon science by this country will be the improvement of agriculture. Research will not necessarily create industry. That is a great mistake. It will not do so. It will add to industries already existing. It will give them new life. It will give them expansion and development, but research pure and simple will not immediately create industries, will not call into life occupations that are not already being pursued in some primitive way.

The only point on which I may touch very briefly, before I conclude, is this. I have had to ask myself since I have been in India what is the value of science teaching that is going on. There is a very great deal of it. Is it the best that could be done? Is it the right thing? Is there something else worth doing? Is there any other direction to which the effort might be turned? I do not want to say too much. I hope when I get home to prepare some state-

ment of a very carefully considered kind upon the subject. But I will say this much, that I have serious misgivings about a great deal of science that is being taught. It seems to me that there is a great deal of science being taught which is not likely to issue in anything practical or in anything really intellectual. The demand at present in this country for the highest science, the demand for the scientific expert, is limited. It must grow. But I think it will only grow in proportion to the industrial development of the country. You must remember that in my own country science lagged behind industry. Industry reached a high pitch of development before science was widely taught. The result was that when we began to teach science industries were already waiting for it. But if you attempt at present to train a large number of men in the highest kind of special science in India, I am afraid you will find difficulty in giving them employment. Well then, if that is so, you will wish to do something less. Now how much less would be of value? My opinion is that the thing that would be most valuable to the country, the thing that is most needed, is the sound teaching of the very elements of science and the dissemination throughout the schools of a realization of what science is and what it can do. Until that knowledge is diffused, until the rising generations of India realize very clearly what science is, what it has done, what it can do, what it may do for this country, the demand will not arise for the highly trained scientist who is to take his place in the development of your industries. Of all the things that I have done at Lahore or tried to do, that which has given me most satisfaction has been a small attempt that I have made to help the science teachers in the schools. And I believe, if I had to prescribe for India the action which I think would tend to the greatest good at the present time, it would be the improvement of science in your schools. Take more trouble in the prepara-

tion of your teachers, give them facilities for introducing a really humane and human scientific teaching, which at present, I am bound to say, I do not think exists. I have no desire to be censorious. I know that science is still new in this country. But I cannot help thinking that a great deal of the science that is being taught at the present time is of a kind which will not produce the specialist and yet will not imbue the person who receives it with the real notion of what the relation of science is to national life. The thing that I believe most essential for you—I do not wish to make it too personal, because it is also true of our own country to a large extent, but it is perhaps more urgently true here—is to disseminate the notion of what the potentialities of science really are.

There is much else connected with science that I should have liked to talk about. There is a philosophical side, and there is the ethical side of science. There is still a tendency to look upon science as a subject that has its dangers. It is apt to be regarded as what we call a bread-and-butter study, a study that lays too much stress upon the material aims of life; one that by its discipline damages the capacity of a human being for appreciating the value of some of the things that are best and highest in life. I have no time to enter upon a defence of science in this respect. I can do no better than once again refer you to the life of Pasteur. No book that I know of will give you a better idea of what science, properly regarded, is in relation to things, not only material, but to things philosophical and things spiritual, and I think if you read that book you will see that science properly regarded may be acquitted of the charges that are so often laid at its door. I have given you a very imperfect plea for science, and a very imperfect account of its true relation to national life. I do ardently believe in science, and I need hardly say I do ardently believe in the necessity

for its cultivation in this country. For I believe that only in science will you find the intellectual weapons with which you can combat the greatest evils from which this country suffers. I need not enumerate those evils. They are sufficiently well known to every one who has the interests of India at heart. But health and industry, clear thinking and courageous thinking, and a love of all that is true and good and beautiful, these things, I believe, result from the right pursuit of science.

*German Science*¹.

NO one can have lived in modern England without hearing continually of the eminence of Germany in science. It is generally supposed that the Germans are much more scientific than we are; that they believe in science more, study it more, pay for it more; that they bring it more into the affairs of life; that they have profited greatly by its application to industry. These beliefs are well founded and just.

Other opinions that are hardly less current on the subject are not true. For example, I have met frequently with the opinions that the leading men of science in Germany far outdistance our own in ability and achievement, that the working men of Germany are specially equipped with scientific knowledge, that the German school curriculum is highly scientific. None of these things is true.

It will be my purpose this afternoon to try and give you an idea of the position which science really does occupy in Germany and of the services which its cultivation has rendered to the nation, and I shall briefly describe the state of things in this country, venturing at the same time a little into the region of criticism.

Any competence that I have to speak to you about German science must be in relation to chemistry, but happily that science is the one in which, perhaps, they are most eminent, the one to which they owe in a special degree material

¹ An address to the Workers' Educational Association, delivered in Leeds July 1913.

prosperity, and one in which their demeanour towards science can be most tellingly illustrated. Let me then briefly indicate to you the history of chemical science in Germany during the last hundred years.

At the beginning of the nineteenth century Germany was not as conspicuous in chemistry as either France or England. Modern scientific chemistry is dated by Frenchmen with much justification from the time of the great Lavoisier, whose career was tragically ended by the guillotine during the French revolution. Englishmen might be inclined to put their countryman John Dalton in the first position. But no like claim has, so far as I am aware, been made by Germany; and though undoubtedly the science was cultivated in that land and many valuable discoveries were made there the nation was conspicuous neither by the eminence of its chemists nor by their number. The first commanding figure which appears in the modern history of German chemistry is that of Justus von Liebig. Of him and his services I shall speak directly, but for the moment I mention him as one who has left an authentic account of the state of chemical science in Germany at the beginning of its great epoch. One part of this account, entitled 'The Condition of Chemistry in Prussia',¹ is so interesting and so significant that I will venture to refer to it in some detail.

Liebig's paper is more of a diatribe than a description. He begins by exclaiming how inexplicable it must be to clear-sighted people that in Prussia, 'a country to which a degree of intelligence and culture is ascribed such as is to be found in few others', it is the Government itself which has not the most distant idea of the importance of chemistry and that all efforts of the teachers are wrecked by want of recognition on the part of those whose duty it is to provide for and

¹ 'Der Zustand der Chemie in Preussen', published in Liebig's *Annalen der Chemie und Pharmacie*, vol. xxxiv, p. 47 (1840).

facilitate the progress of science. 'The cause of this state of things is, however, not difficult to understand. Most of our statesmen have brought from their youth no impression, no insight in regard to science. There was in their day no real science taught. Chemistry was regarded as the handmaid of medicine, to prepare drugs for the physician. Apart from the pharmacist, the science had no existence. The humanistic studies, languages, have with us at all times had the preponderance. They it is which have imbued a whole nation with vanity and conceit about things which stand in no kind of relation to the organic life of the state.'

After bitter reflections on the extravagances and pedantries of the learned scholars and the disastrous effect on pupils whose aim becomes merely to ape their masters, Liebig goes on to say: 'Humanistic studies have become not a means of forming the mind, languages not the keys to the thoughts of lofty spirits of the past, but a sort of fetish in themselves.'

'In the learned German journals you will find that for ninety-nine pedagogical or philosophical essays there is perhaps a single scientific writing. Everybody with any claim to culture understands the ninety-nine, but the science remains a hieroglyph.' He then extols science for the light it sheds on the realm of Nature in which we live, for the impress it makes upon the mind, 'giving a new sense which permits man to discern innumerable wonders which to another remain hidden and invisible.' He recounts the great consequences of Newton's discoveries and explains how by the progress of chemistry revolutionary industrial and economic changes have been effected. And yet 'Prussia, a country in the highest state of culture and intelligence, has no place where the physiologist, the geognost, the physician, the industrialist, the physicist, can learn and become familiar with, the language of natural phenomena. In Prussia there exist no chemical laboratories. The youth are debarred

from one of the most attractive, beautiful, and powerful means for the higher culture of the mind. The present and the future generation have no opportunity to instruct themselves in chemistry; the nation cannot attain to the consciousness of its power to reach innumerable new springs of sustenance and profit, for this is only possible by instruction in chemical laboratories.' Liebig refers in detail to these disadvantages, giving almost incredible examples of the lack of science-teaching and of bad science-teaching. Adverting to particular places, he says there is in Berlin no laboratory where instruction can be received, nor in Breslau, nor Königsberg. In Bonn there is a technological cabinet; in Greisswald nothing but medical chemistry; in Halle nothing. The states will provide no subsidies more than sufficient to pay part of the rent or the cost of fuel. The cost, if the student paid the expenses of chemical instruction, would be quite beyond the means of a German; they might be borne in England or France. 'The solitary man in Prussia from whom practical scientific instruction proceeds, H. Rose, the only one who takes delight and has the talent to make young men into chemists, has an entire lack of means for instruction. His laboratory is a hired place altogether unfit for the purpose assigned to it, of which the Government pays part of the rent; but he has not a penny towards paying the annual outgoings. If Rose desires to teach more than words he gets no pupils, for the charges are too high. For a long time he gave a course of four hours weekly, but he could give no instruction in the analysis of minerals which involved the slightest cost. Even for what he did he was obliged to sacrifice his whole salary and to add something from his private fortune.'

Liebig next alludes to the so-called Trade Schools (*Gewerbe Schulen*) where, as a rule, the teaching is bad, involving no judgement or power of thought—'fit only for day labourers and machines.' 'True scientific education,' he says, 'should

make people receptive for each and every application of it, based on a knowledge of fundamental principles and laws. Nothing is more disastrous than that the single idea of utility should take root in an educational institution and that attempts should be made to convert children at once into soap boilers, brandy distillers, or vitriol makers. These educational follies squander funds without procuring the slightest benefits.' He alludes to the usual attitude of sons of manufacturers who come to him. 'They desire at once to occupy themselves with what they deem to be practical problems, and it is usually with timidity and anxiety that they yield to my advice, put aside all these futile time-frittering attempts, and betake themselves to studying in a fundamental way the art and method of solving purely scientific questions.' He remarks how they wake up to a real enthusiasm for knowledge and how subsequently they find practical applications easy and natural.

'This low condition of scientific instruction explains the low level and unscientific character of agriculture, geognosy, pharmacy, &c. Prussia with six universities has no place for training teachers of experimental sciences, the State provides no place where they may have opportunity for acquiring skill and practice in the art of interpreting phenomena and making experiments.'

'No one can deny,' says Liebig, 'that an overgrown humanism stands above all else against the progress of natural science and scientific medicine, a thing that will be looked back upon half a century hence with shame and a smile of pity.'

He is, however, far from deprecating a true humanistic training; he regards it as a necessity and even as the best and most purposeful preparation of the mind for all other studies. 'There is no better means of awakening the mind, of sharpening the understanding, and exercising the judgement.

Mathematics, and natural sciences give to the child a one-sidedness, to be counteracted fully by linguistic study, first in its form and later by its content in historical and other kinds of knowledge.'

But the strife of the pedants against science is that of the tallow-chandler against the gaslight, of the innkeeper against the express post, of the courier against canals and railways. 'These dull-witted people, strangers to all true humanity, will not have it that the State shall provide means for the citizen and countryman to clothe themselves better or to bear with ease and affection burdens of the State and pay their dues. They will not have it that the doctor shall visit our universities, that he shall derive true value from our lectures, which remain to him, exclusively trained in the grammar schools, wholly unintelligible. They will not have it that industry and commerce shall develop and enrich the State. They fight against materialism, against the utilitarianism of the time, against phantoms of their own imagination.' And yet it is they on whom the natural sciences have conferred the greatest boon. The benignant influence of science during fifty years has enabled the salaries of these people to be raised threefold without causing oppression, poverty, or discontent among other castes, whom they do not regard as human beings because they understand no Greek nor the variants of the Latin authors. To these same creatures of darkness are we indebted for the fact that our theologians only become acquainted with the goodness and infinite wisdom of the Creator out of books, that our lawyers remain detached from the actual life in a State, from its organic development and completion, that their vision is not sharpened, their mind not awakened to discern what is truly useful or truly harmful. To them we owe it that those curious for knowledge in the country, desiring to understand and to be instructed about natural

phenomena, go neither to the priest nor the doctor but to the local forester, because at this day he knows more real science.

Liebig concludes with a eulogy of the policy of the Grand Duchy of Hesse in which his own labours are so warmly favoured by the Government. He prays that the example may be followed, that real schools of science may arise, and that they may develop a new and more peaceful generation, stronger in comprehension and in mind, more receptive for all that is truly great and fruitful. They are to increase the prosperity of the State, for only when man is relieved from the hard struggle for existence and is no more overwhelmed by difficulties, only when it is made easier for him to bear earthly cares, can he direct his mind to higher things.

Such were Liebig's views of the state of his science in Prussia in the year 1840.

I now wish to tell you something of Liebig's own work. His name is no doubt familiar to you all—in connexion with an extract of meat! How many, alas! know of him in any other capacity? I say 'alas' because to know Liebig as the sponsor of an extract of meat and to know only that, is like knowing Wellington merely as the founder of Wellington boots or Gladstone as being connected in some way with a particular kind of leather bag.

Liebig was born in 1803, the son of a dealer and maker of colours. Like so many other distinguished men, he was an unsuccessful and rebellious schoolboy, the real fact being that he had no taste or talent for purely linguistic studies. On an occasion of public reproof he declared amidst the ridicule of his master and class-mates that he would be a chemist. A little later he was sent to an apothecary, but his interest was in chemistry and not in drugs, and after ten months of that life, during which he created constant anxiety by his private experimenting in leisure hours, he was sent back to his

father. At the age of sixteen he went to the University of Bonn and then to Erlangen, where he studied chemistry as well as the circumstances allowed, and graduated at the end of three years. He had already published an original paper of considerable worth, and through the good offices of friends, his merits having become known in high places, he was furnished by the Grand Duke of Hesse-Darmstadt with the means of pursuing his studies. To do this satisfactorily he had to go beyond Germany, and accordingly we find him in 1822 at Paris, where, after working for a year in an undistinguished laboratory, he was admitted through the influence of his great countryman, Alex. von Humboldt, to one of the most distinguished, that of Gay Lussac. A year later, in 1824, again through Humboldt's influence, he was appointed Professor of Chemistry in the University of Giessen, his age being then 21. He stayed at Giessen for 28 years; in 1852 he became Professor at Munich, where he remained until his death in 1873.

Of Liebig's scientific work it is impossible within the time at my disposal to give any precise account, and indeed it can hardly be appreciated by those who are not to some extent familiar with chemical science. I may say in a few words that he will always be reckoned one of the greatest chemists of all time, in virtue of the momentous character of his original investigations in pure chemistry. But beyond this, he was the first to extend chemistry in a rational and far-reaching way into agriculture, physiology, and pathology. It was said of him, on his death, 'If we sum up in our minds all that Liebig did in industries, in agriculture, and in the laws of health, for the good of mankind, we may confidently assert that no man of learning in his course through the world has ever left a more valuable legacy behind him.' Since this was said, another and possibly a greater benefactor, also a chemist, has passed away in the illustrious Frenchman, Louis Pasteur.

There yet remains to record of Liebig the chief service which induces me to lay such stress upon his influence on German science. He was the first man, not only in Germany but in the world to found a great school of instruction in experimental chemistry. His laboratory at Giessen and his methods of teaching were the model on which all chemical instruction, and scientific instruction in general, have since been based, and for many years Giessen was the Mecca to which all chemical pilgrims wended their way. It was there that were trained the first great modern teachers of chemistry in Germany, France, and England. When systematic chemical instruction for students was provided in England in the year 1845 by the establishment of the Royal College of Chemistry in London, the first professor was one of Liebig's most distinguished pupils, A. W. Hofmann.

Again we must note that Liebig's laboratory was not a mere mart of knowledge; it was a centre of inspiration. The study of chemistry was there nothing more or less than the impassioned pursuit of truth. He was a teacher among teachers. 'There was', says Hofmann, 'an earnestness, an enthusiasm in all he said which irresistibly carried away the hearer. Nor was it so much the actual knowledge he imparted which produced this effect, as the wonderful manner in which he called forth the reflective powers of even the least gifted of his pupils. And what a boon it was, after being stifled by an oppressive load of facts, to drink the pure breath of science such as flowed from Liebig's lips—what a delight after having, perhaps, received from others a sackful of dry leaves, suddenly by Liebig's lectures to see the living, growing tree!'

'We felt then, we feel still, and never while we live shall we forget Liebig's marvellous influence over us; and if anything could be more astonishing than the amount of work he did with his own hands, it was probably the mountain of chemical toil he got us to go through. I am sure that he loved us in

return. Each word of his carried instruction, every intonation of his voice bespoke regard; his approval was a mark of honour, and of whatever else we might be proud, our greatest pride was in having him for a master.'

Liebig was also a great popularizer of science. His 'Letters on Chemistry', originally contributed to a newspaper and ultimately collected in a volume, probably did more to extend a knowledge of the meaning and possibilities of chemistry among the intelligent public of Germany than anything that has appeared before or since. They dissipated the notion, still lingering so strongly and persistently in this country, that chemistry is a remote and mysterious study, which, except in relation to drugs and the making of analyses, has little to yield to material needs and nothing to touch the finer instincts of humanity.

I think you will understand how the influence of Liebig and his pupils served to permeate Germany with a real sense of the interest and importance of chemical science. Centres of experimental science arose everywhere; the universities reformed their ways. Those of his pupils who became the heads of industrial concerns found themselves, as he said, with a new point of view, a new attitude of mind, with new weapons, with new means of progress. They came to see that things did not merely happen, that there were unseen but discoverable causes, that a knowledge of causes gave the power of control, of variation, of improvement, of initiation. They had gained all this, not by the narrow pursuit of specialized knowledge, but by whole-hearted and disinterested study in whatever corner of the unknown they were brought by the master mind of a true philosopher to trace the operation of natural laws and to carry their quest to the utmost inwardness of things.

It was this conception of science that got about in educated Germany as it has never done in any other country, and it is

on this that German achievements in science and in scientific industry have rested.

The position of science in the Germany of to-day presents an extraordinary contrast to the state of things discussed and lamented by Liebig.

So far as pure science is concerned, I will restrict myself to very few words. If we take the whole range of the sciences, biological and physical, I think we may affirm that in no country in the world are there so much activity, so many workers and teachers, so much state endowment, so great an output of publications as in Germany. It is the great number of scientific men and the great volume of their productions that are the most noteworthy features.

If you visit the twenty-one German universities you not only find professors of science but you find them surrounded by eager workers, often of mature years, engaged in original investigation, creating a real atmosphere of research. You feel that the great business of the universities is not to retail knowledge but to discover new knowledge and to train young men in the art of discovery. This is very different from our own country, where professors have so much of their time absorbed in teaching or trying to teach pupils the known, rather than training them to explore the unknown, and where in addition they have often to deal with material quite inadequately prepared and sometimes quite indisposed for higher studies. At the same time I repeat, and I say it emphatically, that it is quantity rather than quality that is the distinguishing characteristic of German science. I do not think that any impartial person who surveys the history of science during the nineteenth century will affirm that England has been behind Germany, or is behind Germany now, in the quality of her scientific leaders, or that we have been in any degree behind in giving to science those master ideas and fundamental discoveries which are the great impulses to advance and which

fructify in a host of minor discoveries and in countless practical applications.

We have only to think of Dalton, Young, Davy, Faraday, Joule, Kelvin, Stokes, Darwin, Lyell, Clerk-Maxwell, and Huggins among the giants of the nineteenth century to realize the truth of what I say. And it would be easy to make up a list of those who are with us now that would match the best names of any other country.

In one branch certainly, in physics, we are not only eminent, we are supreme. Radium, it is true, was discovered by a Polish lady in a French laboratory, but the revolutionary science that has arisen from it, the ideas that have thrown an entirely new and unexpected light on natural phenomena and have opened up a new chapter of science will always be associated primarily with the names of an Englishman, Sir Joseph Thomson of Cambridge, and of a son of Greater Britain—a New Zealander, Sir Ernest Rutherford of Manchester. I am proud to add that in the event of the hour our Professor Bragg stands in the very forefront.

It is in followers that we are lacking. If a man has it in him to become a great investigator—if he has in him the subtle spirit of real genius, he will, we believe, realize himself in the face of most formidable obstacles. He will be there ready to lead and inspire. But if the conditions of the time, the temper of thought, and the influence of the State are detached from him, what is he likely to remain but a prophet crying in the wilderness? This has been the plight of most of our English scientific leaders.

I now wish to say something about German science in relation to industries. Here again I shall be compelled by the limits of my knowledge and experience to confine myself to chemistry, but here again I have to be thankful that chemical science is the one which is most widely applicable to manufacturing processes.

It is difficult to name any industry on which chemistry has not some bearing. The use of fuel, the choice of materials for construction, whether in metal or earthenware, the selection and purification of water for steam-raising and all its other manifold uses, the extraction and refining of metals, the making of alloys, the manufacture, indeed, of every material thing—these are all matters on which chemistry has something to say, because chemistry is the science which enables a man to deal intelligently and accurately and economically with all questions that bear on the composition of things.

There is, I believe, hardly a manufacturing concern of any size in which a chemist, properly trained and properly used, would not be worth a great deal more than his salary. It is equally true that there are just as many in which an ill-trained or misused chemist will be an unprofitable servant. But there are some industries which are in a peculiar degree chemical, and in these Germany has shown herself supreme.

Of all the material results of German science, the one best known to the English public is the establishment of what is called the Coal-tar industry. Let us glance at that wonderful development.

The first of the colouring matters now generally known as the aniline dyes was discovered in 1856 by our countryman, the late Sir W. H. Perkin. I need, perhaps, hardly remark that these coal-tar colours or aniline dyes do not occur ready-made in coal-tar, any more than chairs and tables are found in trees. Coal-tar supplies the raw materials from which, by suitable manipulation, the dye-stuffs are elaborated. When Perkin, at the age of eighteen, discovered mauve he was acting as assistant to Professor Hofmann, that pupil of Liebig to whom I have already alluded as having been the first professor in a real professional chemical laboratory in England. The aim of the researches in which Perkin was engaged was purely scientific. He had no intention of turning his chemistry

to manufacturing ends. But here, as is so often the case in science, aiming at the moon a man hits something terrestrial. Perkin discovered mauve, and thinking it might perhaps serve as a dye he submitted it to Pullar's of Perth who replied, 'If (with an emphasis on the 'if') your discovery does not make the goods too expensive, it is decidedly the most valuable that has come out for a long time.'

Upon receiving this reply, Perkin decided to take out a patent and begin the manufacture. His father, as he relates, nobly risked his capital in the enterprise, and after many difficulties and anxieties had been outlived, the works were set up at Greenford Green and mauve supplied to the silk dyers in December 1857.

The discovery of mauve by Perkin was followed by that of magenta on the part of a Frenchman, Verguin, and then came a rapid succession of new colours. The initial difficulties of devising methods of manufacture in a new industry, in conquering prejudices and accustoming the public to a new thing, had been overcome by Perkin, and now the way was easy to his successors.

The prejudices of the time were strong, and they remain with us to this day; everything that could be urged to the disadvantage of the new colours was of course loudly proclaimed, not only by those who had strong vested interests in the natural dye-stuffs, but by that great national reserve of opinion which is always ready to condemn a new thing because of its newness—because it is 'new-fangled'.

The first coal-tar colours that were made were no doubt rather of the showy and glaring kind; some of them also were not very fast either to light or to washing; some of them were apt to be contaminated with arsenic. It was easy, therefore, to get up a cry against them. The cry was loud and it has been long. There are fugitive dyes among both the natural and the artificial products, but to-day it can be

said emphatically that we have artificial colouring matters 'to produce almost any shade with any desired degree of fastness on any kind of material, whether it be wool, cotton, silk, or paper'. The idea that artificial colours are necessarily either gaudy or fleeting is quite fallacious. If evidence is wanted it can be supplied by such facts as these, given by Dr. Duisberg, that in the great Gobelin tapestry factory at Paris, where it takes nearly a year to make a square yard of material, costing about £200, the older dye-stuffs have to a considerable extent been displaced by the artificial ones for the sake of their greater fastness to light. Certain blue dyes discovered in 1901 are authoritatively declared to be the most indestructible colours known.

Perkin's colour factory near London grew and prospered. In 1868 the abstruse researches of two German chemists gave another great impulse by the discovery of the chemical nature of madder—the famous 'Turkey red'. This was followed by the discovery of a practicable method of making the colour. In a short time the cultivation of madder root began to die out, in thousands of acres in France madder growing gave place to the cultivation of the sugar beet, and the manufacture of alizarine (for so the artificial madder was called) grew apace. At this point the necessity of enlarging his manufactory to cope with the increased trade led Perkin to retire. He had always vowed that the lure of industry with its golden guineas should never detach him from the joy of scientific investigation, and so in 1873 he sold his works. From that time till his death in 1907, he continued, happy in his laboratory, to enrich science with his discoveries. He left behind him an honoured name and happily also distinguished sons who have continued in the footsteps of their illustrious father. One of them, I am happy to say, exercises his talents within our own university.

In addition to Perkin's factory, others arose in London and

also in Lancashire. It is a remarkable fact that in the middle of the nineteenth century, the idea of applying science to manufacture was more prevalent in certain parts of Britain and certain sections of British industry than in any other part of the world, and it was easier for a German chemist to find a place in England than in his own country. This is well shown by a fact of great and almost tragic interest—namely that there were then in works round about Manchester three German chemists who subsequently returned to their own country and became the leading spirits in three of the vast concerns in Germany at which we now stand in such amazement.¹

The return of these men to Germany and also the transference in 1864 of Hofmann from London to Bonn and then to Berlin are considered to have exercised a decisive influence on the development of the coal-tar industry. The new industry, it must be remembered, was new in a very wide sense. Not only were new things made, but they were made by methods of manufacture which depended much less on inventiveness and the kind of practical skill in which the Englishman excels, than on an elaborate and thorough comprehension of deep science. In this respect Germany was more favourably situated for the development of the industry than England. Liebig's labours, and the labours of others who followed his lead, had brought into existence in Germany an army of young, enthusiastic, and highly capable chemists who were eager for an opportunity of turning their powers to practical use.

The German industry of preparing pure chemicals, one requiring knowledge and methods akin to those required for

¹ One of these men informed me in the course of conversation a few years ago that he had left England because the firm with which he was engaged showed so much reluctance to support the scientific work he deemed essential for the impending industrial developments.

the colour industry, also gave an advantage. In other respects, the absence of raw material and of large-scale chemical manufacture of such things as vitriol and soda, Germany was at a great disadvantage.

I cannot attempt here to trace the progress of events in any detail. Suffice it to say that before long the colour industry had taken firm root in Germany and had begun a growth which has been nothing less than stupendous, and has placed the nation far before any other in this branch of the practical arts.

Altogether more than 2,000 distinct coal-tar colours have been put on the market and the number is constantly being added to. I can attempt no survey of them and I will only allude to one more in detail, namely indigo.

Most people know, I think, that indigo is a blue colouring matter of great permanence obtained from a plant which has been cultivated to a very great extent in India and used from very early times. The value of the indigo exported from India in a year has amounted to £3,000,000.

The preparation of this colour artificially from coal-tar naturally soon became a hope and aim of the new industry. The chemical nature of the substance was elucidated after much labour, and in 1884 Liebig's successor in Munich, von Baeyer, prepared it artificially. It soon appeared on the market, but did not achieve commercial success. Undaunted by this the German chemists and technologists continued their efforts, and only after more than fifteen years of prodigious labour and the expenditure of vast sums of money, roundly stated at a million sterling, was success finally achieved. It was a wonderful display of talent and enterprise; it has involved incidental discoveries and industrial innovations of great consequence, and is probably as fine an example as could be cited of the triumph of scientific skill intensively directed to a manufacturing enterprise. In 1897, when Germany

began to manufacture artificial indigo, she imported the natural product to the value of £635,000. In 1911 the import had fallen to £22,000, i.e. $\frac{1}{30}$, whilst in 1912 Germany exported her artificial indigo to the value of over £2,000,000. I need hardly say that throughout all this time there have been plenty of voices, especially in this country, declaring that artificial indigo could never equal and never replace the 'good old-fashioned' natural product, and that our apprehensions about a great industry in our Indian dependency were quite uncalled for. These people are now faced by facts that could have been foreseen by any intelligent student of the past.

It is not unusual to hear the coal-tar industry referred to as if it only related to the manufacture of dyes. This, however, is a great mistake. It has gathered round it a great variety of collateral manufactures of the utmost importance to pharmacy, agriculture, photography, and many other practical arts. It is a sort of central region of enterprise for a host of scientific industries and comprises a standing army of industrial pioneers armed with the finest weapons that science can forge.¹

I think there can be no doubt that the development of the coal-tar industries in Germany has had a far-reaching effect on the national attitude towards science, and particularly in this respect—that it formed a gigantic object lesson as to the industrial value of what is called pure science. It must be remembered that the chemists from whose researches these great industries arose were in the first instance men working at scientific investigation in a perfectly disinterested way; they were such men as might fitly be described by terms, which in the mouths of unsympathetic practical men are often

¹ This statement has of course been literally verified during the war, for it has been in these works that the Germans have improvised their manufacture of explosives under blockade and have elaborated the manufacture of poison gas.

meant to be disparaging; they were primarily philosophers and theorists. The industries were related in a particularly clear way to abstruse science; they arose suddenly and unmistakably out of scientific laboratories. Compare them, for example, with some other industry, such as glass manufacture. Glass manufacture did not arise from scientific investigations; it grew from primitive times and evolved gradually in the hands of practical men. Its connexion with science is not apparent; people do not readily believe that it is as much a chemical operation as is the most high-sounding experimental transaction in a university laboratory; just as they cannot believe that water is as much and as truly a 'chemical' as is Para-amido-benzene-azo-ortho-oxy-benzoic acid.

Whilst therefore it might be difficult, and it usually is difficult, to persuade a manufacturer of glass that a man trained in high science is likely to be a profitable ally, there could be no such doubt in connexion with the coal-tar industries. The consequence was that these new German works made a constant demand on the very ablest, the most ardent philosophers among university students of chemistry.

I think you will agree that if we had to convert a stiff-necked generation of industrialists to a belief that science, even of the most forbidding aspect, is worth consideration as what is called a business proposition, the most persuasive eloquence could hardly equal in effect the spectacle of a group of industries with a capital of twenty-five millions openly declaring that they were made and sustained by high science, all of them paying a steady dividend of something like twenty-five per cent. I believe that as a matter of fact the influence of such a state of things in Germany has been most potent. It is true, no doubt, that before the coal-tar industries arose there was in Germany a disposition to encourage the study of science for its own sake, there was a disposition to associate it with industry; but such tendencies have been greatly

exalted and encouraged by what has happened in these specially chemical industries.

Be that as it may, the spectacle of German industry to-day discloses an intimacy and degree of association between science and practice such as the world has never seen, and such as is not yet approached in any other country.

So much then for the coal-tar industry. I have dwelt upon it because it represents the most conspicuous German success among manufactures which depend upon the appreciation and application of science.

It must not be supposed that it is the only example that could be adduced. On the contrary, it is only one of many, and, indeed, it might have been more instructive if I had chosen some other industry with which we are more familiar in this country to show how, by the application of science, the Germans have succeeded not only in making themselves independent of nations to which they formerly looked for their supplies, but have gone further and proved themselves successful rivals as manufacturers for the outside world. One hears the alarm sounded on every side, and even in industries in which we have been inclined to feel a natural and unassailable pre-eminence, authoritative opinion now gives us reason to abandon our complacency.

I desire to speak with moderation and with all due reserve. I am well aware that a man of science is not entitled to dogmatize about industrial affairs. I am well aware that men, impressed by the successes which have followed the application of science to industry, tend to underestimate other factors of success. Nor am I disposed to repine about British industry. I see many signs of vigour and enterprise. The statistics of trade are wonderful. I know too that there is a constant and rapidly increasing tendency to apply science to industry in this country. And yet, when every allowance is made, I think it may be affirmed with the utmost confidence that

German industry, taken as a whole, exhibits a vastly greater and more effective application of science than our own.

It will be obvious to you that my account of science in Germany has been very partial and imperfect. The whole subject is, of course, far too large for one man and one hour. I have chosen to speak of the science with which I have some acquaintance. But I believe I am warranted in saying of all science, that there exists in Germany the same regard for it as for chemistry. It is believed in for its own worth as knowledge; it gains the suffrages of the people and abounding support from the State. It is regarded as the ally and not the enemy of practice, and it is turned to practical account zealously in every way for the furtherance of material well-being.

Things are by no means so in England. We have, as I have said, no lack of scientific genius. We have, and have had, great men who initiate, men whose discoveries mark epochs in the progress of scientific knowledge, men often more celebrated in Germany than they are here. Many of the ideas for the application of science to industry have come from Englishmen, many of the industrial applications have begun here. But the belief in science either for its own value or for its material usefulness is greatly lacking.

Science in Britain derives splendid support from certain units and sections of the manufacturing world, but, broadly speaking, the manufacturing world is not behind it and does not use it as it might. I dislike nothing more than from my position inside a university to seem to speak disrespectfully of our leaders of industry. It is apt to be resented and it may do more harm than good, but it is sometimes a duty to be disagreeable, and I feel I should be keeping something back that you are entitled to hear if I did not tell you that it has happened repeatedly to me in my life to see individual industrial undertakings languish and sink when they might

have been saved by the knowledge and guidance that science could have supplied. It is difficult to substantiate such a statement, impossible, of course, to adduce the very instances. But I do not make the statement lightly or hastily. It expresses what is to me not a mere surmise but something as certain as anything can be that from its nature cannot be absolutely proved.

If I am asked to go to the root of matters and say what I really believe it is that has underlain English neglect of science, I am afraid I should enter into regions where my cause might be better served by silence than by speech. I will therefore tell you frankly that I will not say all that is in my mind. There is a tacit understanding among the teachers of our university,—and I believe it is a very wise one,—that we put some restraint upon the public expressions of our purely personal opinions. But this much I may say freely, that the pursuit of science in this country has been subject to uneasy suspicion. Of the forms of suspicion I will only mention two.

I daresay some of you may know that in the University of Oxford an honour student of natural science is commonly known among other sections as 'a stinks man'. It is, of course, a playful term, which it would be ridiculous to take seriously. At the same time there is many a true word spoken in jest, and much serious opinion may be concentrated in words that can be given to a child to lisp. I do not believe that the terse expression to which I have referred was invented by an undergraduate. I think it much more probable that it came as a bright inspiration to some prodigiously learned don and was quietly dropped by him in some undergraduate's room. If I do not know the very don in question, I know his double, nay, his centuple.

What I mean is this, that science as commonly taught, as commonly pursued in this country has not seemed edifying to the man of letters; and the man of letters, until these later

days, has been the supreme influence in the great seats of learning, that have dominated our education and have trained the leaders of our national affairs.

I say that the man of letters has not found science edifying. I have often heard him say with extraordinary composure that he knew nothing at all about it, much in the same way that the best-dressed aristocrat in the House of Commons once explained in the course of a debate, that he had never been an agricultural labourer. Science has not gained the regard of the man of letters—not only because of the suspicion that it would tend to divert people from literary studies, to which, rightly enough, he attaches vast importance; but because the thing in itself has not seemed to confer much benefit on the human mind or the human spirit, however far its applications might minister to material well-being.

Now I do not quarrel altogether with this point of view. It is perfectly true, in the first place, that science has had to adopt an aggressive attitude. It has had to struggle and to fight against tremendous obstacles for recognition not merely as a worthy but as a legitimate subject of study. It has had constantly to assail deep-rooted prejudices and trench on vested interests, and so what is naturally a peaceful pursuit became associated with the idea of idol-smashing and aggression. Besides this, it is only fair to admit that science has been taught and practised by multitudes of people in this country in a truly unedifying way, and bad science is, I think, the most unprofitable mental food that can be administered in the name of knowledge or culture to any human being. A man may outlive a diet of tough irregular verbs, hard-boiled literature, unleavened history, and philosophical dish-water, and yet become a speaker of languages, a lover of books, a student of the vital past and a reflective inquirer into the operations of the mind. Later experience of the realities of life may in these things beget a clearer vision and give a new

and better standpoint from which a man may begin his studies afresh. But machine-taught science, such as our universities, especially that of London, have condoned, and such as the happily defunct agency of the Government Science and Art Department spread like a plague through our schools—that, a man does not recover from easily if at all. For science is not taught by experience of life; only the want of it is made evident; and it cannot be gained by taking thought and sitting down in leisure hours to read a book. Science can only be learned in laboratories, and if that opportunity has been lost or vainly used in early life it does not ordinarily recur.

How often does not one come across a man who says—‘Oh yes, I was taught some science at school—sulphuric acid H_2SO_4 —or was it H_2O ?—but, of course, I have forgotten all about it.’ It has gone, forgotten, unhonoured and unsung—not deeply regretted. It never was a reality—it was attached to nothing interesting, nothing human. It could not grow; it could only wither and die.

I do not wonder, therefore, that science has made such little appeal to the sympathies of men of letters; it has so often seemed to be nothing and to come to nothing, towards endowing a man with knowledge, taste or talent of any value.

But I think that science has been suspected even when it has been good—that is to say, when it has been so well studied and practised, that it has been an unmistakable addition to the resources of the mind, when it has become productive in new knowledge, when it has opened new vistas and made almost incredible intellectual conquests in the realm of Nature.

There is a widespread belief, more often hinted than openly declared, that the pursuit of science is accompanied by the development of habits of mind and tendencies of practice which would derogate from the most precious elements in human nature and in the amenities of human society.

This is an old theme on which much has been said and

much has been written, in comparison with which any words of mine must sink into insignificance. It is the fashion to pretend that the belief exists no longer. Science, it is said, has gained the day; it is the modern study; it is the one towards which money is most freely devoted. This is only partly true. The support that science has received in these later times is, I am afraid, not in the wide sense disinterested. It is believed that science pays. And so it does, and so it may be commended. As citizens of a country that we desire shall survive, we who pursue science are anxious enough that it shall be known to pay. But we want much more than that. We want science to be appreciated for its own sake. And I boldly say, it is not so appreciated by any manner of means. I say it is distrusted. If you ask for proof, I might reply that it lies in the constant experience of my life. If you insist upon a sample, here is one. At the conclusion of a very able article appearing not long ago in a newspaper on the subject of London University, we find the following:

‘The report is a masterly production, and if we disagree with it on the points indicated, it must be admitted that it errs in conformity with a tendency characteristic of the age—the tendency to close unrecognized doors, straighten roads and regulate everything in a “scientific” spirit—a tendency which may ultimately have very much to answer for.’

The word scientific is in inverted commas. That I take to mean that it is not used in the right sense, as *The Times* puts General in inverted commas when it speaks of ‘General’ Booth.

Please understand that I do not quarrel with what I have quoted. On the contrary, I believe it is entirely in harmony with my own view—namely, that the common and wrong idea of science is that of something rigid, mechanical, unimaginative, and something cramping to the human spirit. Science may be this if it is misconceived and misused; it may tend to make a man or a nation narrow and one-sided, blind to other things as great as or greater than itself. But so,

surely, may be, and has been the case, with the pursuit of purely literary studies.¹

Of all the distinctions that I dislike, none seems more misleading than that of calling literary studies the 'Humanities'. It leads almost inevitably to the inference that the rest of knowledge consists of inhumanities. I would not say a word of disrespect for the so-called humanities, for I have no disrespectful thought concerning them—as I conceive they should be, and as they really are apart from pedants. The proper study of mankind may be man; and human history, the human wisdom of our forefathers, human piety and human poetry, the study of the human mind, will always have their assured place. But outside man stands the rest of Nature, the Universe. The exploration of that, the unravelling of all the phenomena of the Heavens and the Earth, the revelation of natural law that was before man was, that will remain when man may well have ceased to be—that surely is a study which should not be belittled by any exclusive term. That surely is not a study which, properly conceived and properly pursued, will make a man or a people arrogant, mechanical, unimaginative or impious. The time I think may come when everyone who now rightly thinks himself in darkness if he has not some love or knowledge of the humanities, will be not any less ashamed to be heedless or ignorant of the natural sciences, which, if it is desired to denote them by a single word, might, I think, without any impropriety be called the divinities.

The danger of science undoubtedly lies in the rich material fruits that it inevitably sheds in its luxuriant growth. These are a temptation to the carnal mind, and I would say as soon as anyone, Woe be to the man or to the nation that sets its heart on these alone!

Such a danger may be said to exist in modern Germany,

¹ It cannot be too emphatically stated that the school discipline of Germany was not based on scientific studies. (January 1921.)

I do not know. Certainly it is felt by some people. I gave you at the outset of this address some quotation from the writings of Liebig when in 1840 he lamented the national disregard of science. To this it is only fair to set in contrast some modern utterances made sixty years later by men not less devoted to the interest of their country: ¹

‘Two souls dwell in the German nation’, writes Professor Paulsen; ‘the German nation has been called the nation of poets and thinkers, and it may be proud of the name. To-day it may again be called the nation of masterful combatants, as which it originally appeared in history.’² That is true, but an addition is needful, for the struggle to which Germany has since 1860 devoted its undivided strength is not a struggle waged consciously in the name and for the sake of civilization, is not a struggle for intellectual or political ideas, or ideals of any kind, but a struggle for sheer mastery in the realm of matter and for political ascendancy amongst the nations. Yet if Germany should ultimately gain all the material success and political power it aspires after, no one will dare to say that it will mean more for civilization and the world than the weak and disjointed Germany of a century ago, which gave to mankind the Goethe and Schiller, the Kant and Fichte whose teachings have for the time been cast aside.

‘One recognizes with anxious apprehension’, says another writer,³ ‘that the active interest for natural science and technical improvements is not balanced by a deeper concern for the problems of the mental sciences and the arts, which, in truth, can alone beneficially appropriate the achievements of technical culture; that in every department of German life a tendency to be satisfied with externals is visible, and the

¹ I make these quotations from the well-known work ‘The Evolution of Modern Germany’, by Mr. W. H. Dawson (Fisher Unwin, 1908).

² *Zur Ethik und Politik*, p. 59.

³ *Unser Kaiser und sein Volk*, by a ‘Schwarzseher’ (‘Pessimist’), p. 155.

endeavour after knowledge and self-realization is lacking; that we have, indeed, made progress in the domain of industry, commerce, and material life, but, on the other hand, the old German quality of striving after the essence of things, the hidden soul of phenomena, and the delight in this endeavour—free from all secondary ends—is more and more being lost; that we have lost the old idealism and in its place have put phrases and pomposity and high-sounding words.’¹

‘A one-sidedness which only esteems material values and an increasing control over nature is destructive in its influence,’ wrote Professor Dr. Rein, of Jena, recently, ‘and this one-sidedness set in during the second half of the nineteenth century in Germany. We Germans have ceased to be the nation of thinkers, of poets, and dreamers, we aim now only at the domination and exploitation of nature . . . Have we Germans kept a harmonious balance between the economic and the moral side of our development, as was once the case with the Greeks? No; with the enormous increase of wealth dark shadows have fallen on our national life. In the nation as in the individual we see with the increase of wealth the decrease of moral feeling and moral power.’

‘At the beginning of the nineteenth century,’ writes Professor Paulsen, of Berlin, than whom no one has more right to speak upon this subject, ‘speculative philosophy was in the ascendant, and with it went humanistic philology, both being one in that their aim was contemplation. At the end of the century natural science was predominant, and natural science in the service of technics and medicine. One has only to notice the increase of technical colleges and the expenditure which the State incurs on behalf of science;—for new institutes of natural science and medicine, new millions are always ready, but is any liberality shown towards the most modest need of philology or philosophy?’²

¹ *Unser Kaiser und sein Volk*, by a ‘Schwarzseher’ (‘Pessimist’), p. 155.

² *Zur Ethik und Politik*, p. 62.

A consideration of German science leaves us with much to honour and admire and much to muse upon. I have found a great tendency on the part of those who have come fresh from its atmosphere, ardent with the enthusiasm of youth or with the impatient and unreflective zeal of hasty reformers—a great tendency to insist that we should forthwith Germanize our science. I hope profoundly that we shall do no such thing. I will only name one direction in which, I think, we are already showing that we are wiser and may do better. The most conspicuous educational outcome of the German scientific and industrial movement has been the establishment of their technical universities, so often extolled both in Germany and here. I would like to say frankly I consider technical universities to be an educational mistake and a national danger of the first magnitude. Efficient they may be within a particular range of human efficiency, but universities, it must be remembered, are the dominating influence in national education. It is in them that the greatest number of minds which will control the nation are tutored. The ideals that are fostered there will be carried out into the world and impressed upon the national life. Will anyone maintain that great institutions, given over entirely to the teaching of science and especially of science in relation to purely material ends, will form an environment in which the leaders of the working world may be best prepared to serve their time and generation?

There is surely no more mischievous idea than that a university should be a place where a man is fashioned into an efficient piece of mechanism, where he is made simply clever, and is sent out to be accurately fitted like a cog-wheel in what is sometimes called the machinery of civilization. It is a desolating doctrine of education and a godless view of life.

When we hear our great men—such a man, for example, as Lord Morley—speak so tenderly and reverently of Oxford, do you suppose that he is thinking of it as a place where he learnt political economy or history or literature? By no means.

He thinks of it as a temple of disinterested learning, a place haunted by the spirits of mighty men, the place where the flower of English youth assembled, young men with different destinies, different hopes, different ideals, who got to know one another, influenced and stimulated one another, where character was formed and strengthened, aspirations gained, and the whole man influenced for good service in the world.

My praise of our old universities is always qualified. I believe they sadly neglected their duty to science, that they allowed themselves to grow much too aloof from the work-a-day world and the occupations that engage the bulk of our people.

The new universities are relatively small, and they cannot claim yet to have in any great measure the greatest virtues of the old. But in their closer association with the industrial world they have, I believe, an enormous advantage. The University of Leeds is often spoken of as a technical university. It is no such thing. It is a university in which those who are engaged in literary, scientific and technical studies dwell together in union and harmony. We set out deliberately to avoid one-sidedness, we seek to gather together a community of all interests, and we believe that in our mutual influences we shall preserve a fair balance; that we shall produce neither the literary pedant, too superfine to sympathize with the realities of life, nor the narrow scientific technologist with a view of knowledge limited to the service of material ends.

In this way I think we shall do better than Germany, and whilst cultivating science, shall avoid its detachment and intensive cultivation for practical ends apart from other realms of knowledge. We shall keep its votaries sane, large-minded and in sympathy with all that is worthy and elevating to the human spirit, and make them better able to gauge and meet the complex and varied needs of a nation striving not only for greater prosperity but for truer civilization.



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