There is a widespread feeling that it is too academic, and must be made more practical. In any case, it must aim at developing character and intelligence rather than merely imparting book knowledge.

If it is urged that further time for schooling is commercially impossible, it must be remembered that our great trade rivals, the Germans and the United States, have compulsory continuation schools or a higher exemption age. In Germany it is the custom for parents to put their boys to a skilled trade, and apprenticeship is as flourishing there as ever it was. "The Imperial Law on the 'Regulation of Industry' of 1891 decreed that the masters in any branch of industry were bound to allow their workers under the age of eighteen to attend an officially recognised continuation school . . . for the time fixed as necessary by the authorities." The local council might make such attendance obligatory for all male workers under the age of eighteen. Every raising of the school age or Factory Act limiting child labour has been in turn objected to as fatal to industry, but the community has very quickly adapted itself to the new conditions.

The removal of the supply of cheap boy labour under fifteen would probably lead to very useful readjustments of industry and to the substitution of mechanical labour for some of their work and for a greater employment of adult labour. It is, of course, true that to start boys at fifteen instead of thirteen or fourteen will not prevent a period of transition from boys' to men's jobs, but it will give a better chance of skill to the boy. A better and longer education should give the boys firmer and more disciplined characters and a greater power of adapting themselves to new work. Increase of efficiency, even in unskilled labour, means increased wage to the mutual benefit of employer and employed. It is the over-supply of unskilled labour which is not worth a good wage which is the real difficulty.

Again, in skilled trades proper there is little doubt that there is room for more boys, and they are not supplied now with the best material available. It is probable that labour exchanges for boys leaving school would be of very great value in securing that all the more intelligent and able boys had a chance of securing good openings. It is the ignorance of the boy which so often leads him into employment which is not suited to him.

Further, some better grading of wages is most desirable. At present, comparatively high initial wages are often paid to tempt boys into an unprogressive occupation. The value of the old apprenticeship scales lay in their attempt to make the wage increase with the capacity, but the low initial earnings have been the reason of the unpopularity of apprenticeship with the more needy and less far-sighted. It is quite possible that the boy leaving school at fifteen will still not earn more than he now does at fourteen. There is little doubt that in that case the employer would gain, because he would get a better article, but the boy would also gain, because he would be a better article and more fit to develop into a still higher efficiency, commanding better wages later. It is better that he should be paid less in his early years and be worth more as an adult. Under existing conditions he is bribed by large wages to spend his time on uneducative work which gives him no opportunity afterwards, and he is unfit to spend wisely the large wages which he receives. The present system demoralises the boy. The temptation to leave one job to get higher wages in another is almost irresistible, and the resulting instability is detrimental to himself and not economical to his employer, who is perpetually trying to train new boys.

EVOLUTION IN APPLIED CHEMISTRY.[1]

EVERY chemist, to be worthy of the name, should in his own work be a specialist; but there are few amongst us to whom it has been given to produce in their own particular line of research results of deep general interest. Our distinguished president, Sir William Ramsay, is one of the privileged few; I am one of the many, whose scientific results are like the grains of sand, the importance of which lies in their aggregation.

But a chemist, to be worthy of the name, should also be able to step forth from his own small sphere of activity and to look upon his science and allied domains of human thought as a whole, to contemplate its history and its future, its aims and progress, and to glean a few useful truths from such considerations. This is what I shall try to do.

The simple daily wants of mankind in a primitive condition are all supplied by nature. It is the progress of civilisation which led to the necessity of transforming her gifts, and thus created a chemical industry. Human chemical work supplements the chemical work of nature, and is therefore subject to the same governing laws. It is strange that no attempt has yet been made to trace the many coordinated points which exist between biology, the science of life, and chemistry, the science of molecular changes, without which life is an impossibility.

The subject is extensive enough for a book. I cannot hope to do justice to it in a short lecture, but I shall try to point out some of the relations existing between the results of biology and applied chemistry.

Biology as a science is of very recent date. The manner in which our forefathers tried to gain an insight into the overwhelming variety of the vegetable and animal kingdoms was purely systematic. Linnæus, de Candolle, Cuvier, and others, enabled us by their systems to classify nature, but they did not teach us to understand it. Hardly a century ago the dawn of a deeper insight began to rise on the horizon of science, and just fifty years have elapsed since that memorable meeting of the Linnean Society in which the flaming truth of evolution was given to humanity by one of the greatest minds that ever stood up amongst men. Botany and zoology, the pedantic histories of plants and animals, became suddenly united in biology, the great science of life, itself a living thing, capable of development and evolution.

Evolution is no longer a working hypothesis of natural science; it has become a new way of thinking, a method of harvesting everlasting truth from the fleeting changes of passing life. It is not applicable to living plants and animals only, but to everything that is capable of growth, alteration and improvement. Why should this method not be extended to the study of human achievements, of science as a whole? Why not to applied chemistry, which is so full of changes, and more vigorous in its growth and development than many another discipline?

It seems to me that England, the country which has given to all the other nations the invaluable gift of evolution, is the classical soil on which an attempt might be made to apply it in a new manner. It may help us to understand, and therefore to forgive, the struggle for existence, which in chemistry and its applications is as rife as amongst the organisms of the deep sea or the tropical forest. Looking at that struggle with the calm soul of the man of science, we shall easily recognise the underlying promise of the survival of the fittest and of certain progress in coming days.

As a rule, one takes it for granted that anything applied must have existed before its applications. It is not so with applied chemistry. Chemistry as a science is, as we all know, a comparatively new creation. Its applications, on the other hand, have existed since times immemorial, and may be traced back to the very beginnings of human civilisation. The men who in the past devoted their thought and energy to problems which we now call chemical had to reach their ends with the help of sound empiricism. Though their progress was slow it was sure, so that to this day we have sometimes occasion to marvel at their successes. More than that, we may safely say that some of our best industrial methods would never have been discovered if we had had chemical theory only to guide us. Science itself stands on an empirical basis—we cannot draw general conclusions unless we have well-established observations to start from.

It is perhaps not superfluous to remember these facts at the present time, when the brilliant success of theoretical chemistry is apt to make us forgetful of the services derived from purely empirical methods of research. Empiricism investigates without foregone conclusions,

[1] Address to the combined sections of the Seventh International Congress of Applied Chemistry on Monday, May 31, by Prof. Otto N. Witt, of Berlin.

whilst theoretical science verifies logical deductions. Science forces nature to divulge its secrets; empiricism is quite content to pick up the treasures it may come across in its ramblings through unexplored regions. Nature is still full of unknown treasures. Why should we cease to search for them? Why should we expect success only from logical deduction?

It is true that the scientific method of invention is a quicker road to success. Rapidity is everything in our times. Whirling along in a motor carriage to a well-known destination is distinctly more agreeable than tramping on foot in the glaring sun of a summer's day; but you cannot pick the flowers blooming by the roadside or stumble over hidden treasures at the rate of sixty miles an hour. The two methods of progress have both their own peculiar advantages, and should both be followed. Now and then they will meet, and make success doubly certain.

One of the best combinations of empiricism and theory is the examination of old empirical industrial processes by the methods and in the light of modern chemical science. A great deal of valuable information has been obtained in this way; much more remains to be discovered. It is this conviction which led me to propose to the last congress at Rome that a special section should be established in these congresses for the history of applied chemistry. The history of chemical science, as it exists now, is almost entirely devoted to theoretical systems and to the life of those who created them. The history of industrial methods is not so complete as one might wish it to be.

So far as the history of our nineteenth-century chemical industry goes, the materials for studying it are not wanting. The patent literature of the various countries is in itself an inexhaustible source of information, which can be largely supplemented from text-books and endless files of periodicals; but it is not so if we begin to inquire into the applied chemistry of previous centuries. The mysterious communications of the mediæval alchemists have been frequently examined; but Pliny remains our almost exclusive source of information about the chemical arts of the antique world. Yet these arts were many and highly developed, and Pliny's information was distinctly superficial.

How much more might be gathered about the chemistry of past times has been shown by the researches of such men as Berthelot and Edmund von Lippmann, who combined the accomplishments of distinguished chemists with those of the Orientalist in the study of Arabic and Hebrew authors. Who knows what a host of information may yet be lying dormant in unread Egyptian papyri and palympsests?

But the sovereign means of discovering these lost secrets is in the careful study and analysis of the products which ancient times have fortunately left us as proofs of their skill and knowledge. How much has been done in that respect by that one great master, Marcellin Berthelot, who found in such work the recreation of the later years of his life? How much more remains still to be done?

Thus we may hope to know at some future time more of the accomplishments of past generations than we do at present; and we may also hope that some of the methods thus re-discovered will awake to fresh life like mummy wheat, which is said to take root and grow if you plant it in fresh soil. Have we not greeted with delight the *terra sigillata* of the Romans, when the process for its manufacture was re-discovered by Fischer, a Bavarian potter, and has not a considerable industry sprung from the resurrected use of lanolin, or wool-fat, which was a panacea of the Greeks two thousand years ago?

Yet such discoveries will remain inheritances from the dead, and the cases of their resurrection to life will not be numerous; but we have living empiricism at our doors, which we allow to die and to sink into oblivion, without attempting to study it and to learn the lesson it has to teach—a treasure of information of incalculable magnitude hoarded up in the course of centuries by the skill and patience of countless millions of men who were, and are, as keen in the study of nature as they are reluctant to draw general conclusions from their observations.

This great treasure is the industrial experience of the Eastern nations. It is an undoubted fact, and if it were not, a single visit to the South Kensington Museum would prove it, that the people of Persia, India, China, Japan, the inhabitants of Burma, Siam, Cambodja, and the innumerable islands of the Pacific, are possessed of methods for the treatment and utilisation of the products of nature which are in many cases equal, if not superior, to our own. These methods must be to a large extent based upon chemical principles. Is it not strange that we know so little about them, and that little generally only indirectly through the accounts of travellers who were not chemists? If all these peculiar methods were fully known and described by persons who have seen them applied and watched their application with the eyes of a chemist, it would certainly be, not only of interest, but also of the greatest utility to our own industry; for it is the elucidation of empirical methods which, in the new light that science sheds upon them, leads to new departures and to progress. Who can deny the advantage which the industry of cotton dyeing and calico printing derived from the study of the Turkey-red process, which a century ago was bought as an Eastern trade secret by the French Government and generously placed at the disposal of European dyers? Would the making of porcelain have been invented in Europe if the impulse for it had not come from the East? Is there no connection between the introduction of Chinese porcelain and the invention of Delft, the curious observations of Réaumur on devitrification, and even the work of that great and original genius, Josiah Wedgwood? And would that supreme triumph of the application of pure chemical science to industry, the synthesis of indigo, ever have been accomplished if indigo, as a natural dyestuff, and its extraordinary method of application by vat-dyeing, had not come to us from the East? What a stir has been created, even in these very latest days, by the extension of this ancient Eastern method of dyeing to other shades than those of indigo!

We live in a period when the intellectual nations of the East wake up from their political sleep of centuries, when they issue from their seclusion and demand their share of Atlantic civilisation; but their awakening means going to sleep for their industrial methods. These methods, ingenious as they undoubtedly are, cannot compete with ours in being applicable on a manufacturing scale. So our processes are transferred to the coasts of the Pacific, and their own methods are abandoned and forgotten. The Eastern industries cannot keep pace with ours, not because they are inferior in their results, but because they toil on foot whilst ours are motoring. In this struggle for existence the fittest means the quickest and the cheapest.

Yet I am certain that many a new and good result might be obtained from the combination of Eastern and Atlantic achievements. Examples of such happy blending are not missing. See what that great and original English inventor, Lord Masham, the very type of an Atlantic genius, has made of the wild silks of India!

It seems to me that these international congresses ought to make it one of their important duties to watch over the intellectual wealth of the past and to collect it before it disappears for ever. Let the chemists of all countries who flock together in these gatherings entrust to their keeping the old indigenous industrial methods of their nations; let the reports of these congresses, which are distributed over all the world, become a treasure-trove of ancient motives for new development!

If we consider how our present chemical industry has been evolved from empirical processes such as our ancestors practised them, and as they still exist in the countries of the East, and even in some parts of Europe, we can easily observe a gradual transformation similar in many respects to the one that living nature had to go through in evolving the present types of plant and animal life. It is here that the parallels between biology and chemistry offer themselves. They are interesting, and not useless to consider. It would be strange indeed if we could not gather some acceptable hints from surveying the broad expanse of the human toil and thought of centuries.

One of the most characteristic changes that have taken place is the transformation of handicraft into manufacture.

We have replaced personal skill by division of labour in chemical work just as much as in all the other branches of human industry. In so doing we have certainly unconsciously copied nature. Do not her earliest creations, the unicellular organisms, in which one cell is made to fulfil all the functions of life, resemble the patient craftsman, who works at the object that he wants to turn out from the beginning to the end, and then, with a last loving glance, hands it over to his client? And are not our factories of the present day comparable to the complicated organisms of the later epochs of creation, with their many coordinated and subordinated organs that work in unison, and in their joint activity are much more powerful than their tiny unicellular ancestors?

One of the most interesting chapters in the evolution of animated life is the gradual transformation of aquatic organisms into those living in the air and on solid ground—a tremendous change, and one which could only be effected by many and varied attempts and by means of the most marvellous adaptations. Right into the midst of our epoch, when the conquest of land as a permanent dwelling-place for plants and animals is practically accomplished, reaches the perpetuation of intermediate forms, which can adapt themselves to land or water, as the circumstances may require.

Now what is the lesson we can learn from the study of this wonderful development in comparing it to what has happened in our own industry? I think it is obvious and of the greatest importance. It is this, that no industry, and especially no chemical industry, can be transplanted, such as it is, from the place in which it has been successfully developed, into any other without having to undergo a complete change, which taxes to the utmost the organising and inventive power of those who make the attempt.

This is a truth too often forgotten in our times, when the keenest struggle for success is rife everywhere, and people who have to suffer from the competition of factories established in other countries are apt to vent their grief in uncharitable accusations. Yet how frequent are the examples, when manufacturers, who have risen to great prosperity, suffer tremendously by transferring their own business into some new locality. In many cases it is merely a move in their own country, yet it means, generally, a far-reaching adaptation to altered conditions; but if it becomes a question of transplanting a manufacture from one country into another, it must be quite a new creation if it is to be a success. As a new creation it should command our respect, and though it may be inconvenient it should not be disparaged. It was the destiny of aquatic organisms to conquer land as a dwelling-place, and it is the destiny of the industrial countries of the present day to carry industry to the nations that are ready to receive it.

There are, fortunately, no two countries alike in this world, and most of them differ, from a manufacturing point of view, more than land and water for plants and animals. Whenever an industry leaves its native country it has to be re-modelled. Take, for instance, the gas industry, which was born in England, and has been carried by English enterprise over all the world. No sooner it crossed the channel and was established in France and Germany than it had to be materially transformed, not in its principle, but in the constructive details and the dimensions of the necessary plant. Our coal was different from yours, our fire-clay had to be prepared and worked differently for the production of the necessary retorts, our condensers and gas-holders had to be altered and encased to withstand the sudden and wide changes of temperature of a Continental climate, our yields proved lower, and the economy of the process was materially different. Still greater changes awaited the gas industry on the other side of the Atlantic. Though the United States are possessed of good gas-coal, the freights for it to the New England States proved to be too high. On the other hand, anthracite was incomparably cheaper there than it is with us, and the same was the case with mineral oils of a high boiling point. All this led to the successful substitution of carburetted water-gas for the illuminating gas of Europe. At present we try hard to acclimatise this American adaptation of the gas industry both in England and Germany. Brilliant as the work done by gas specialists in connection with these attempts undoubtedly is, the success is, to say the least, indifferent, and will remain so until the water-gas question will again have undergone so complete a transformation and adaptation to European industrial conditions that it will once more be paramount to a new creation.

Another example. Just at the present time a new country is about to join the concert of industrial nations. Norway, in the rocky solitudes of which the bear was wont to ramble and the elk and the reindeer to graze, the blue fjords of which knew no other craft than fishing smacks and occasional pleasure yachts, is beginning to develop a chemical industry of vast dimensions. Will that industry be similar to the one existing in this country or in Germany? Certainly not. Its factories will have no chimneys, no fires. They will be activated by the "white coal," the force of roaring torrents. Our engineers have pondered over the problem of economically transforming heat into electricity; the task of the Norwegian manufacturer is just the reverse. One of the fundamental problems of our German chemical industry is the utilisation of our overwhelming wealth of sodium and potassium salts; the Norwegians neutralise their synthetic nitric acid with limestone, because they have no cheap alkali. Many other points of the same kind might be mentioned, but I think these are sufficient to show that, whatever that new Norwegian industry may prove to be, when fully developed it must be different from what the world has seen so far.

The first activity which the human race develops in taking possession of wild districts is agriculture, and we know full well that no two countries are alike in their agricultural methods and results. An agricultural country has to develop a dense population, and, in its work, the peculiarities due to its soil and its climate, before it can attempt to create an industry. The blending of the old agricultural interests with the newly acquired industrial ones means in itself a convulsion. Is it then probable that so fundamental a change may be brought about by the mere importation of a miserable copy of what has been born and nurtured to maturity on other soil and under another sun?

If we study the life of plants and animals we are struck by the marvellous economy reigning everywhere. There are few physiological processes which can be called wasteful. Every bye-product of the more important chemical reactions that take place in the organisms of plants and animals is utilised and made to serve some purpose. In plants, for instance, the refuse of the chemical work of the protoplasm seems to be deposited as encrusting material in the enclosing cellulose. The encrusted cell is then made to serve as a mechanical support for the body of the plant, whilst new and more vigorous cells are formed to fulfil the functions of life. Some of the bye-products of the chemical work of the plant are transformed into dye-stuffs, others into perfumes, both with the object of attracting the insects which are necessary for fertilisation. Everywhere in animated nature we see the principle of storing up food, either to serve in cases of need or to provide for a future generation. Even in those cases where nature seems to be wasteful, as, for instance, in producing germs and seeds in far greater numbers than seem to be required for the continuation of the species, the seeming superabundance is merely a wise calculation of the probabilities for the development of the germs. More marvellous, perhaps, than any of these examples is the economical use of the energy required for sustaining the functions of life. So far as I am aware, there is not a single engine of human invention which can utilise the energy supplied to it in so perfect a way as, for instance, a horse utilises the calories contained in its food for the production of mechanical power; and though the mechanical equivalent of light as a form of energy is, so far as I am aware, yet an unknown constant, we may safely say that the perfection with which living plants utilise the energy of sunlight for carrying out the endothermic reactions upon which their nutrition and growth depends is far superior to the methods which we have so far discovered for similar purposes.

Are not these principles of economy which so universally pervade living nature also the very essence of all industrial chemistry? Are not such considerations as economy of energy in its various forms, high yields, and the avoiding, or, if unavoidable, the utilisation of bye-products the fundamental principles which we try to instil into the mind of the young chemist about to begin his career as a manufacturer? The history of applied chemistry is teeming with examples where the survival of the fittest means neither more nor less than a victory of economy.

We all know that that marvellous creation of human ingenuity, the closed ring of industrial chemical processes working in connection with Leblanc's method of producing soda, is practically extinct on the Continent and materially reduced in its importance in England. This fate it had to suffer, because it was a wasteful process—wasteful in its utilisation of material and wasteful in its consumption of energy. The skill and resource exerted in its invention and constant improvement will for ever be gratefully remembered; but they were unable to check the progress of the Solvay process, which is more economical in its use of energy, and of the electrolytic methods for splitting up the alkaline chlorides, which produce no bye-products.

The progress of industrial chemistry does not always depend on the introduction of more perfect, but also more complicated, machinery and plant into the factories. Of course, every chemical process requires thorough working out from a mechanical point of view, and many of the most brilliant successes of our modern chemical industry are mainly due to a clever adaptation of mechanical means to a chemical end; but, taken as a whole, the real progress of the chemical industry does not so much consist in the improvement of the apparatus as in the simplification of the fundamental chemical reactions. More than once a seemingly insignificant chemical alteration of an industrial process has produced the same or a better effect than the introduction of the most ingenious and costly plant.

That the great principle of economy is not only applicable to the material necessary for carrying out chemical reactions, but perhaps even more to the energy consumed by them, is a distinctly modern idea. It is not so very long since we have begun to have, if I may say so, a conscience for fuel. Previous generations took it for granted that industrial work consumed coal, and that the necessary coal had to be provided and to be paid for. We are now awake to the fact that the quantity of fuel required for an industrial process is very much dependent on the way in which it is made to do its work.

Of course, the calorimetric effect of any given fuel is a constant, and it is also true that we can never utilise more than a certain proportion of it; but this proportion may vary considerably. It was alarmingly small almost through the whole of the nineteenth century, and we may congratulate ourselves upon its present ascendent tendency. A striking example of the transformation of our views about fuel and its proper use is the history of the smoke question. There was a time, both in England and on the Continent, when smoke was considered a necessary evil which had to be suffered. After a while smoke began to be looked upon as a nuisance, and war was declared against it by those who suffered from its disagreeable properties; but now we know that smoke is a waste, and that nobody has better cause to wage war against it than he who produces it. A smoking chimney does not only carry visible unburned carbon into the atmosphere, but in nine cases out of ten also invisible carbonic oxide and methane, with all the latent energy they contain. Smoking chimneys are thieves, and their misdeeds should not rise unavenged to heaven.

But even chimneys that are innocent of incomplete combustion may be guilty of stealing energy if they allow the gases of combustion to escape into the atmosphere with a higher temperature than is necessary to activate the draught. The lost energy of such gases may be trapped and recovered by the regenerating and recuperating apparatus now so largely used by many industries. Regenerative gas-heating is not only a sure prevention of smoke, but also the most powerful means of economising heat, and therefore one of the greatest acquisitions of modern industry. It is perhaps not saying too much that the saving of national wealth effected by it may amount to a sum sufficient to pay the aggregate national debts of all the civilised nations. Uncivilised nations are blessed with neither national debts nor heat-regenerating appliances.

My last comparison between biology and applied chemistry I should like to choose from a chapter which one might call biological sociology, though I am not aware that that name is commonly given to it. It treats of the wonderful phenomena of symbiose and aggregation.

Symbiosis is, as we now know, of very frequent occurrence. Plants or animals of totally different nature and organisation, or even plants and animals, may combine for joint life and activity with the object of helping and protecting each other in the great struggle for existence. What neither of them would be able to fulfil or obtain by its own strength and power they can do with ease and certainty in their faithful allegiance. Gregariousness—the flocking together of organisms of the same kind—arises from the same spirit of mutual help and protection.

There is a great deal in human life and institutions, in our morals, politics, and science, which reminds us that the human race, as an intrinsic part of animated nature, has also inherited its all-pervading tendency for combining forces; and what is thus apparent in the doings of mankind in general cannot be absent in the special field of activity which forms the object of our exertions. The various forms of chemical industry are essentially symbiotic. They depend upon each other for their success and progress. A solitary chemical factory in a country otherwise devoid of chemical industry is a practical impossibility. Chemical works come in shoals if they come at all. The maker of acids and alkalis wants other chemical enterprises to use his products, and these, again, are constantly on the look-out for customers. The more varied and numerous the factories are, the more they prosper, in spite of their complaints of growing competition.

The chemists themselves are gregarious. They form societies and academies and institutes and syndicates by the score, and who can deny the fact that brilliant results have been achieved by such combinations of forces? If we remember, in terms of unmeasured gratitude, the great originators of our science and its applications, we cannot forget the help rendered to its progress by such institutions as the Royal Society and Royal Institution, the French, Italian, and German academies, the leading chemical societies, and the innumerable universities in all parts of the world, the rapid growth and extension of which is the true gauge of our progress.

Last, but I hope not least, in this list of brilliant aggregations stand our congresses as a new, but most successful, creation. They represent a modern form of symbiotic effort amongst chemists, which is the more remarkable because it is international. They proclaim the great truth that science knows no boundaries and frontiers, that it is the joint property of all humanity, and that its adherents are ready to flock together from all parts of the world for mutual help and progress. It is the great truth proclaimed by one of our past presidents, Marcellin Berthelot—"La science est la bienfaitrice de l'humanité entière"—which our congresses might write on their banner, for it expresses the spirit which led to their foundation and ensures their success.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

DR. H. KOBOLD, professor of astronomy at the Kiel University, has been called to the similar post at Berlin.

MR. J. E. BARNARD has been appointed lecturer on microscopy in the department of general pathology and bacteriology, King's College, London.

DR. G. S. WEST has been appointed to the chair of botany and vegetable physiology in the University of Birmingham, rendered vacant by the retirement of Prof. Hillhouse.

PROF. W. W. PAYNE has retired from the chair of astronomy at Goodsell Observatory, which he founded at