the transmitting end or in the receiving apparatus. An example of this latter method is Poulsen's ticker.

The question whether receiving apparatus can be arranged so as to receive messages from stations equipped with the spark apparatus and from stations equipped with the arc apparatus is a matter of enormous importance at the present moment in view of the probable ratification of the Berlin Convention, which imposes an obligation on all commercial stations to inter-communicate without regard to the make or system of transmitting apparatus employed. I am of the opinion that there will be no difficulty in carrying this into effect provided that the stations using the spark method send out long trains of waves, as they should do to obtain syntonic working, which is also called for by the Berlin Convention.

An extremely interesting development which is now progressing rapidly owing to the possibility of producing continuous oscillations by the arc method is wireless telephony. Suppose that we can vary the intensity of the oscillations in a manner corresponding with the vibrations of the air which constitute sound and speech, then we should obtain at the receiving stations a train of Hertzian waves the amplitude of which varies in a corresponding way; by allowing these waves to act on a telephonic receiver which is sensitive to the intensity of the waves we shall obtain in the telephone a reproduction of the sounds. This has actually been carried into effect by employing an ordinary microphone to modify the current through the transmitting arc so as to vary the intensity of the oscillation current produced, and by employing what is known as a point-detector and a telephone at the receiving station.

Another method which may be used consists in causing the microphone to vary the frequency of the oscillations of the generator, and by arranging the receiver so that it is more or less strongly affected according to the frequency of the received waves.

I am informed that experiments have been made in wireless telephony in Berlin by the Amalgamated Radio-Telegraph Company between their stations in Mathieu-strasse and Weissensee, 6·5 km. apart, with good results, and that it is now proposed to equip the stations at Oxford and Cambridge for the further perfecting of this application.

It is greatly to be desired that wireless telephony may develop rapidly, as it seems to me that for the purpose of communicating with ships wireless telephony will have great advantages over wireless telegraphy.

I am deeply indebted to Mr. Colson for all the facilities that he has placed at my disposal, and to his engineers for their assistance, which has enabled me to carry out the experiments in the lecture; and I have also to thank the Tramway Department for the special supply of current.

THE BRITISH ASSOCIATION.

SECTION K.

BOTANY.

OPENING ADDRESS BY PROF. J. B. FARMER, M.A., F.R.S., PRESIDENT OF THE SECTION.

CUSTOM has decreed that those who are charged with the responsibilities that to-day fall to my lot should endeavour to address themselves to the consideration of matters such as they may deem to be of advantage to others, or, at any rate, of interest to themselves. It is not, perhaps, always easy to combine these two courses, and if I choose the less altruistic one I experience the smaller compunction in doing so because the undisturbed repose that most Addresses enjoy when they have been decently put away between the covers of our Annual Report seems to indicate that an attempt to express the passing thought, however ephemeral its interest, may not be the worst introduction to the business of the advancement of our science.

Any attempt to give a survey of the progress and present position of botanical science, even were so large a task at all within my power, has almost ceased to be necessary, owing to the enterprise which has so admirably provided for its adequate fulfilment elsewhere. I propose, therefore, to try to put together, in a form as intelligible as I can, the result of reflections on some of the aspects of botany that are often not seriously regarded; perhaps because they belong rather to the nebulous region of speculation than to the hard (and sometimes dry) ground of accepted fact.

I am by no means blind to the risks incurred in venturing on such a course, but I believe that a glance directed, however imperfectly, towards some of the less obvious sides of our science may not be altogether futile, even though the attempts should evoke the criticism:

Dum vitat humum, nubes et inania captat.

The problems that confront us as botanists are far more numerous and far more complex than formerly. We are attached to a science that is rapidly growing, and this rapid advance is carrying with it a process of corresponding differentiation. Some years ago a danger arose, even within this Association, that we might have replaced differentiation, that quality which distinguishes the higher organisms, by a process of fission which is more characteristic of the lower ranks of life.

The products of the threatened fission would doubtless have pursued divergent paths, and the botanist of to-day would have been the poorer for it. He would have been lost to physiology, and all that physiology implies. Happily that danger was averted, and, to our lasting advantage as members of the botanical organism, our science escaped disruption, and physiological investigation still continues both to inspire, and to be aided by, other branches of botanical research. A physiological conception of morphological phenomena is the one that to me seems to afford the broadest outlook over our territory. It serves to check a tendency towards mere formalism on the one hand and to correct the not less baneful effects of a superficial teleology on the other. Both are real dangers, and we have all encountered examples of them.

In rating highly the value of maintaining a physiological attitude of mind towards the phenomena presented by the vegetable kingdom, one is mainly influenced by the logical necessity which such a position carries with it of constantly attempting to analyse our problems, as far as may be possible, into their chemical and physical components. It seems to me that this is the only really profitable method that we can bring to bear on the difficulties that lie before us, because in using it we are constantly forced to consider the *causes* which have led to the final result. Of course I am well aware that to some minds the very attempt to apply such a method beyond a very limited range may appear futile, or at least premature. But the goal of all scientific inquiry lies in the ultimate ascertaining of cause and effect, and only with this knowledge can we hope to get control over the results.

Chemistry and physics each present to their followers problems far more elementary than those with which we have to grapple; but the explanation of the great advances which these two branches have made lies essentially in the fact that an analysis of the factors involved has enabled the investigator intelligently to interfere with, and so to control, the mode of presentation of the reacting bodies to each other. And our own special problems, whether we confine ourselves to the simpler ones, or whether we approach the obscurer matters of organisation, heredity, and the like, are assuredly susceptible of a similar method of treatment. We can never expect to get further than to be able to modify the mode of presentation to each other of the materials that interact to produce what we call the manifestations of life; but the measure of our achievement will depend on the degree in which we are successful in accomplishing this.

Indeed, until we have analysed the nature of the reacting bodies, and also especially the particular conditions under which the reactions themselves are conducted, we are avoiding the first steps in the direction of ultimate success. At present, when we desire to know the taxonomic value of this or that character, we are perforce largely guided by purely empirical considerations. We find, for example, that a particular structure is very constant through a group of species otherwise closely resembling each other, and we rightly (but quite empirically) regard the possession of that character as a valuable indication of affinity within that alliance. But the very same feature in other groups may be highly variable, and lack all importance amongst them for systematic purposes. It may be, and very probably is, optimistic to look forward to the time when we shall know *why* the character is good in one, and worthless in another, alliance. But when we do, I am convinced that the reason will be found to lie in chemical and physical causes. We are very ignorant as yet of the details, but we can nevertheless even now form a fair guess at their general nature.

In this connection I would venture to express the opinion that much real harm is done by the toleration of an uncritical habit of mind, all too common, as to the significance of structures which are regarded as adaptive responses to stimuli of various sorts. It is *not* enough to explain the appearance of a structure on the ground of its utility; properly speaking, such attempts, so far from providing any explanation, actually tend to bar the way of inquiry just where scientific investigation ought to commence.

That many of the responses to such stimuli are of a kind to render the organism "adapted" to its environment no one, of course, will dispute; but to put forward the *adaptedness* as an explanation of the process is both unscientific and superficial. The size and the spherical shape of duckshot are admirably adapted to the purposes for which duckshot is used; but this affords no insight into the necessary sequence of cause and effect, which makes the melted lead assume the characters in question as it falls down the shot-tower.

But many people still find consolation and satisfaction in an anthropomorphic and somewhat slipshod application of a kind of doctrine of free-will to matters that really call for rigorous examination into the causes which, under given conditions, must inevitably and of necessity bring about their definite result.

One of the commonest responses to the stimulus of wounding in the higher plants is the formation of a layer of cork over the injured and exposed tissue. No one can deny that this is a reaction of great utility, checking as it does the undue evaporation of water and the entrance of other parasitic organisms. And yet I suppose that no one would go so far as seriously to maintain that the obviousness of these advantages satisfactorily explains *why* the cork layer is produced. It seems to me that an investigation of the real underlying conditions which govern such a modified reaction would be of immense value, and that the information we might gain therefrom as to the nature of the chemical processes involved would prove to be of first-rate importance in tracking to their sources some of the factors that influence the course of carbohydrate metabolism within the cell. Again, we know how easy it is to produce colour-changes in the leaves of certain plants—*e.g.*, rhubarb—by severing the vascular bundles, and thereby interfering with the process of translocation. Overton has shown how the accumulation of soluble carbohydrates within the leaf of such a plant as Hydrocharis modifies the metabolic processes within the cells. Thus in bright light, under conditions of cold sufficient to arrest starch formation, but not enough to stop photosynthesis, a red-coloured substance makes its appearance in the cell, and this again disappears on raising the temperature, so that the accumulation of soluble carbohydrates diminishes. The red colour which is associated with the change may possibly by absorbing the heat ray aid in restoring metabolism to its "normal" course; but such a teleological explanation is not of general application, and gives no real insight into the nature of the processes involved. The well-known laboratory method, which we owe to Klebs, of inducing Eurotium to enter on a sexual phase by keeping it at a temperature of 26° C. is another example of the same order. The particular reaction that occurs in each of these instances is that which necessarily results under the specified conditions, and no other course of chemical change is possible.

In the last-mentioned example, Eurotium acts in a way similar to that of drought, only the result is more quickly produced. This perhaps indicates that we are dealing with a definite series of changes which are inhibited by the presence of too much available nutriment supplied at a temperature too low to enable it to be sufficiently rapidly altered within the organism so as to give rise to the specific substance, which is more directly responsible for the ascogonial phase of the life-history. Something of an analogous character is probably effective in the formation of "fairy-rings," so typical of the growth of certain agarics. This appearance of fairy-rings may be easily reproduced in artificial cultures of moulds by appropriate means. Thus if the nutriment agar be kept fairly dry, so that the rate of diffusion of soluble materials is slowed down, it is found that concentric zones of sterile and sporiferous hyphæ regularly alternate with each other. An explanation of this behaviour, which seems most probable, is that the hyphæ, after they have been growing over the substratum for a certain distance, have acquired sufficient raw material to provide for the building-up of the substance which stimulates spore-production. When this has taken place the substance so elaborated is used up and spore-production ceases until a fresh supply of material, under the conditions of the experiment, has been formed to act in its turn as a new stimulus. This suggestion is supported by the interference with the circular form of zones that can be brought about by artificially interfering with the rate of diffusion of the supply of nutriment in the jelly. The rhythmical alternation of sterile and fertile zones seems to prove that *quantity* of elaborated material is an essential factor in the process, just as in the stimulation of a motile organ the stimulus itself has to reach a certain minimal intensity in order to cause a movement.

The parallelism between the nutritive, *i.e.*, the chemical, stimulus in the case of the fungus and the minimal time-stimulus required to provoke geotropic movement is very striking. For it will be remembered that there is evidence in the latter instance also of the occurrence of a definite chemical change as the result of the disturbance of normal gravitational relations. This finds expression in the accumulation of homogentisinic acid as the result of the formation of an anti-oxidative substance which arrests the complete disruption of tyrosin in the cells. Whether this is the immediate cause of the geotropic movement, or merely a concomitant of it, we cannot settle at present. But it is of the highest interest to know that chemical change is initiated as a result of the external gravitational impulse, even when the latter is of too short duration to produce an actual geotropic movement. And although we may not at present be able to identify the exact material which is directly concerned in these stimulatory or formative processes, we have, as it seems to me, irresistible evidence in favour of its real existence. It is more than mere analogy that leads us to believe that the various kinds of galls, for example, that may be formed on an oak leaf owe their formation to the specific interference of the secretion of the grub with the higher metabolic processes going on in the cells of the leaf.

I have alluded to the different conditions under which given reagents may interact, and these may in turn very materially affect the final result by modifying the course of the reaction itself. We are coming to realise the fact that the physical conditions of the cellular constituents exercise an important influence on the course of chemical activity manifested within their range. We all know what an important part water plays in ordinary chemical reactions, but the water question assumes a special prominence when the reactions are going on in a colloidal matrix, or rather in a mixture of colloids, such as the various proteins that occur in the cell. Questions of rates of diffusion, physical absorption, and the like have to be taken into account; and beyond all these there remain the series of remarkable electrical relations which the proteins exhibit, as well as those changes in surface-tension that are, in part at least, connected with them.

It is impossible to resist the belief that a closer study of the physico-chemical changes that accompany a nuclear division will yet throw much light on the mechanics of this wonderful process. Indeed, we already possess some data which are serving as starting-points for further investigation, and they have placed some of the known facts in a very suggestive light.

It has often been urged as a reproach against the histological methods employed in the study of the cell that all such investigations can, after all, only give information as to the character of coagulations or precipitations. Of course this is perfectly true; but provided we have sufficiently good grounds for enabling us to feel confident that the precipitation or coagulation faithfully maps out the positions originally occupied by the respective colloids during life, there is no real force in the objection. No one would call in question the accuracy of a photographic negative on the ground that after development it no longer consisted of the actual substances which had been formed in the film by the exposure to the action of light. All that is required is that the deposited silver shall accurately express the limits of, and be proportionate in amount to, the alteration in the composition of the salt which was produced when the plate was exposed in the camera.

Much of the general detail of a nuclear division can be followed even in the living cell, and we therefore possess direct as well as indirect means of testing the degree of accuracy with which the fixed preparation represents the original pattern of distribution of the colloids within the cell. No one who has studied the behaviour of artificially prepared mixtures, the colloidal proteins and nucleins after "fixing" and staining them, can entertain reasonable doubts as to the substantial identity of the structures visible in a well-fixed cytological preparation with those present during life. For the substances, even in these artificial mixtures, keep remarkably distinct, as indeed Fischer showed some years ago.

Few things are more striking than the remarkable series of evolutions passed through by the linin, and by the chromosomes which finally emerge from it during the progress of a mitosis. We have clear evidence that the nucleus at this period is the seat of rapid chemical change. The process of distribution of the nuclein within the linin is sufficient proof in itself of this. But we have also, I believe, evidence of physical disturbances of an electrical nature which accompany, and indeed in a measure determine, the course of mitosis. This is indicated, not only by the movements that proceed within the nucleus, and concern the linin and chromosomes, but also by the remarkable alterations in surface-tension exhibited by the nuclear membrane.

It is well known that at a certain stage of the heterotype division, for example, the chromosomes move to the periphery of the nucleus, and each one is removed as far as possible from every other chromosome. At this stage, to which Haecker has given the name of "diakinesis," the nucleus reaches its maximal size. Diakinesis is not the only stage in which there is an indication of repulsion between the elements of the chromatic linin. Measurements prove that all such periods of repulsion are also marked by an increase of nuclear size which is transitory, and either disappears or alters in a synchronous fashion with them. These phases of enlargement have been generally regarded as directly connected with the intake of liquid by the nucleus, due to a hypothetical change in osmotic conditions. But, so far as I am aware, no satisfactory explanation has yet been given as to why, or how, the supposed increase of osmotically active molecules within the assumed semi-permeable nuclear membrane could be effected. On the other hand, an enlargement of the surface-membrane of the nucleus would necessarily follow on the migration towards it of chromosomes or other bodies carrying similar electrical charges. For the induced charge in the particles of the membrane would of course weaken its coherence, for the same reason that the free chromosomes repel and move away from one another.

There is evidence to show that the proteins *are* able to carry such charges, and this is a matter of the highest importance as affording a clue to many other processes in which changes of surface-tension play a part, besides those connected with nuclear division.

Not the least of the many remarkable properties exhibited by the proteins lies in their capacity of taking on either a positive or a negative charge of electricity. A clear proof of this was afforded by the beautiful experiments of Billitzer, who showed that, when so charged, the colloid moves as a whole towards one pole or the other on sending a current through the liquid in which it was suspended. At first sight it may not be easy to understand how it is possible for a colloid to receive and retain a charge under the conditions which obtain either in the solution or in the cell. It must, however, be remembered that the liquid contains electrolytes in solution also, and any disturbance in the equilibrium of the products of ionic dissociation will be accompanied by corresponding differences of potential. The most reasonable explanation of the phenomenon in question seems to be that the colloids are unequally permeable to the ions, whereby there comes to be a preponderance of one or the other group associated with the proteins. Perhaps this should be connected with the remarkable though still imperfectly understood property of adsorption which is characteristic of many colloids.

Much, however, still remains to be done before a complete survey of the electrical changes that are associated with mitosis can be made. We especially desire more complete information on the nature of the chemical processes which are involved. For it is obvious that the physical changes must ultimately be connected with the transformation of materials which goes on so energetically at these recurrent periods of nuclear activity. We do not yet know how or why the chromosomes that have been dispersed at diakinesis should again congregate on the spindle prior to their final separation. Possibly this is to be connected with the signs of disturbance in the extra-nuclear cytoplasm, which in its turn finds expression in the differentiation of the achromatic spindle. The character of this body has long aroused the suspicion that its existence is to be attributed to electrical causes. The more recent work serves to indicate that this suspicion was well founded.

The more complete study of the chemistry and physics of karyokinesis is certain to prove valuable for another reason. The successive changes which the nuclei of both animals and plants exhibit when they are undergoing division are so remarkably similar that it seems exceedingly probable that the processes actually involved may turn out to be relatively simple, at any rate in their broader features. I mean that they probably belong to what we might term the lower grade of metabolic problems. For the great uniformity of the process as a whole, complex though it undoubtedly is, hardly suggests direct relations as existing between it and those more specialised forms of metabolism on which the properties of specific form, and such like characters, depend. This view of the matter is not in any way weakened by the fact that the materials providing for the multiplication of nuclei have themselves passed through the very highest stages of anabolic construction. There are, indeed, some grounds for believing that the composition of the higher proteins is distinctly specific for different groups of organisms; but apart from this it is difficult to resist the conviction that, in so far as its essential constituents are concerned, the nucleus is the seat of a complex organisation which is superadded to its chemical composition. But this conception of the nucleus does not affect the position of the lower-grade chemical changes, with their physical accompaniments which are periodically rendered apparent during the rhythmical series of changes that culminate in the division of the nucleus. It is true that there are some who refuse to admit the necessity of what I might perhaps call architectural complexity in protoplasm. They prefer to regard all the phenomena of organisation and heredity as the outcome of dynamical, rather than of structural, conditions. It seems to me that it is impossible to reconcile such a view with the known facts respecting the inheritance of characters, and that we are driven to postulate the existence of material units which are to either responsible for the sum of the characters represented in any individual. There are grounds for believing that their entities, whatever be their nature, are doubled, and then equally distributed to the two daughter cells at every ordinary nuclear division; and thus the properties of organisation are preserved and transmitted over and above the flux of chemical change.

Most people who have concerned themselves with cytological studies agree that the salient features of karyokinesis strongly emphasise the probability of a conservation of definite material; and that an extremely accurate distribution of it occurs where two daughter cells arise from a parent cell by division. And this inference is greatly strengthened by what occurs, more or less immediately, in connection with the formation of the sexual cells. The origin of these in all the higher animals and plants, as is well known, can invariably be traced to a nuclear division of remarkable complexity. In this, the so-called heterotype division, the special feature consists in the sorting-out of the nuclear constituents originally furnished by the two parents of the individual. This sorting or distribution takes place in such a way that each of the two daughter nuclei which arise as the result of the division receives only half the total number of chromosomes previously contributed by the two parents. The essential point of interest lies in the fact that the process does not consist in the mere halving of nuclear *substance*, but in the distribution of nuclear *constituents*. When two sexual cells which have been formed in this way unite to give rise to a new individual, the total number of nuclear chromosomes is again made good; but the resulting nuclear constitution will not exactly resemble that of either parent. That such is really the case is borne out by innumerable experiments that have been made by breeders. Furthermore the extensive investigations on the results of crosses, both in animals and plants, have confirmed the view that particular characters can be treated as entities. For they are distributed amongst the posterity of the original parents in proportions that closely approximate to mathematical expectation. In this distribution the separate characters behave independently. For instance, the green colour and round form of peas are two characters which may occur in the same or in different individuals. The numerical proportions in which they *will* appear can be foretold with a considerable degree of accuracy.

With these facts before us—and many others could be adduced, all pointing in the same direction—it is not easy to resist the conviction that within the nucleus there must exist material entities which are severally responsible for the appearance of the characteristic traits of any given individual. The question is, What conception can we form as to their nature, and how are they able to produce the observed results? It is not necessary to discuss the evidence that the chromosomes, or the materials of which they are composed, play a most important part in connection with development. All the work of the last decades has tended to emphasise their importance in the transmission of hereditary qualities, and this is equivalent to admitting that they contain factors that determine the path of development, and are responsible for the production, from the egg, of the form and structure of the adult.

Now it is certain that it is not the *chromosome-substance acting as a whole* which is effective in those processes summed up in the term Ontogeny. It might be, and until recently was, thought that in those plants in which there is a marked alternation of generations a definite relation existed between the number of the chromosomes and the particular stage of the life-history. The double number was supposed to be essential for the sporophyte, whilst the halved number was similarly regarded as causally related with the appearance of the gametophyte or prothallial generation.

But Loeb and others had already shown that the eggs of echinoderms might be stimulated to parthenogenetic development by means other than fertilisation, and Wilson found that such larvæ only contained the half number of nuclear chromosomes, as, indeed, was only to be expected. But the idea of a close parallelism between chromosome number and the alternative phases of the life-history was so deeply rooted that the full significance of Wilson's discovery was not at once grasped. The comparative neglect was, perhaps, partly justified, inasmuch as the larvæ could not be reared. It may, however, be incidentally remarked that no one, so far as I am aware, has yet succeeded in raising the *normal* echinoderm larva beyond the pluteus stage.

The investigation of cases of apospory that occur in the pteridophytes have proved that no causal relation can exist between the number of the chromosomes and the characters that distinguish the gametophyte and the sporophyte respectively. For the sporophyte may give rise to the gametophyte aposporously without any reduction, whilst the various types of apogamy with which we are now acquainted exhibit all gradations between a coalescence of more or less differentiated nuclei and the complete absence of all semblance of nuclear fusion. In the latter case, when the sporophyte springs from a gametophyte that has itself arisen after nuclear reduction, the sporophyte continues to retain the smaller number of chromosomes normally associated with the other generation only.

We thus have a complete proof that a single sexual cell which has undergone reduction in the number of its chromosomes retains, in so far as its architectural configuration is concerned, the capacity of giving rise to a plant possessed of the full complement of characters belonging to the species. But this, after all, is only what the facts of heredity might have led us to anticipate. For, whilst we are ignorant of the fundamental *significance* of the sexual fusion of the gametes, one of its most obvious *results* consists in the duplication of the primordia of the specific characters in the cells of the individual thus produced. This statement is not only in accord with results of experiments in breeding, but it is also in harmony with the essential features of the heterotype mitosis; and no other satisfactory interpretation of the latter series of phenomena has yet been found.

Furthermore, the facts of Mendelian dominance clearly show that each parent, through the gametes to which it gives rise, contributes an independent organisation responsible for at least some of its own distinctive characters, as well as those which distinguish the species. Consequently, when two gametes fuse, the embryo will be provided with a duplicate stock of agents or primordia which determine the appearance of its own specific and individual characters. These will not always be similar in the two parents, and when this is the case it often happens that the offspring resembles one parent only in respect of a particular feature. Nevertheless the results of further breeding show that the corresponding, but apparently lost, character only is latent, for it reappears in a proportion—and often a fixed proportion—of the individuals of the succeeding generations. In such an example, where both agents or primordia are present, one of them lies dormant, whilst the dominant one alone influences the course of metabolic processes, and thus brings about the appearance of the character itself. The dormant primordium can be transmitted as such through many generations, betraying its existence in each by the occurrence of individuals in which it finds its perfect expression. This happens when the opposite dominant agent or primordium has been removed from some of the gametes by the sorting-out process during the heterotype mitosis to which I have already alluded.

The particulate character of inheritance seems, as many writers have pointed out, to demand a structural organisation for its basis; and the units or primordia of which the latter is composed must be relatively permanent, inasmuch as heredity itself is so stable. The agents or primordia themselves probably act by definitely influencing the course of chemical reactions that proceed within the living protoplasm, somewhat after the fashion of the ferments. But whether this influence on the course of metabolism is to be attributed more directly to the chemical or the physical aspect of the organisation must, of course, remain an open question, though I incline to the latter alternative on grounds which I have already indicated.

The processes of the higher metabolism offer suggestive analogies with those reactions for which the ferments are responsible. In contemplating them one can hardly fail to be struck by the orderly way in which ferment succeeds ferment on an appropriate medium. Each one produces its own special change, which it is unable to carry further itself, but it thereby provides a substratum suitable for its successor. Starting, for example, with a complex substance like cane sugar, we see it acted on by a series of ferments, each the result of protoplasmic differentiation, and each one carrying the process of disintegration a little further, but strictly limited in its power to act, and only able to take the change on to a definite stage.

Everyone who has experimented with plants with the view of inducing the formation of some structure foreign to the species or individual by artificial means must have become impressed by the great difficulty of getting into touch, so to speak, with the higher metabolism at all. It is often easy enough to divert the life-history into either the vegetative or the reproductive channel, as every gardener is more or less consciously aware, and as Klebs has conclusively shown in his remarkable series of carefully conducted experiments. But even here it is sometimes difficult exactly to hit off the conditions requisite to ensure the production of one or other of the various phases of the life-history. There are many fungi, for example, which are believed to represent vegetative stages of Ascomycetes or Basidiomycetes, but it has not yet been found possible to ascertain the conditions that would cause them to form the highest fructifications. Even in simpler instances a similar difficulty is sometimes encountered. Thus *Bispora moniliforme*, a mould that often occurs on the wood and stumps of oak or hornbeam, is not readily cultivated as the Bispora form, whether it be grown on wood or on various nutritive media. The usual result of raising it under artificial conditions is to obtain a luxuriant crop of Eurotium-like mould. But the Bispora form can be reproduced from such a culture by growing it in strong solutions of cane sugar under certain conditions, all of which are not as yet understood.

I take it we shall agree that the properties of structure and form are to be interpreted as the necessary result of the action of particular substances on the protoplasm, and that these cause it to assume those definite attributes which we term specific on account of their constancy through a larger or smaller range of individuals. But this constancy of form must then be the result of a corresponding definiteness in the series of changes undergone by the raw materials supplied as food in their upward transformations; each stage in the process limits the possible range of those that follow, as in the case of the ferments to which I have alluded; and thus it becomes increasingly difficult to modify the final result.

In this way we may see, perhaps, an explanation of the circumstance that in amphibious plants the particular structure, whether adapted for land or water, that will arise in conformity with the environment is irrevocably determined long before the organs themselves are sufficiently developed to be exposed to the direct influence of the conditions to which they are supposed to be specially adapted.

Now it is a matter of common knowledge that the formative processes can be, and sometimes *are*, disturbed with the most surprising results. I may again refer to the fungal or insect galls as examples that will be familiar to everyone. It appears to me that these exceptional developments are of extraordinary importance in relation to any endeavour to probe the mysteries of organisation. The very difficulty experienced in imitating the effect of the insect's secretion strongly emphasises the specialised nature of the particular substance which is able to modify the "normal" reactions of the plant. The latter are dependent on the way in which the organic apparatus determines the fashion of the molecular presentations, so that, as I have said, the course of the reactions themselves become increasingly limited in their range. Now as regards the manner in which the secretion of the insect operates, it seems clear that it can produce no permanent change in the organising apparatus of the protoplasm, since the growth is at once arrested on the removal or death of the insect. But whether the influence is one that more directly affects the physical state of the apparatus for the time being, or whether it acts more directly by introducing new substances into the final chemical reactions, are questions which are plainly worth investigation, but at present certainly do not admit of an answer.

Another example of interference with the developmental processes is afforded by the well-known "lithium larva," which was discovered by Herbst to arise when the eggs of some species of sea-urchins are allowed to segment in sea-water that has been altered by the addition of lithium salts. The monstrosity produced under these conditions was just as constant and specific in character as are the different galls which can be induced to develop on an oak leaf by the corresponding species of insect.

Extending these considerations a little further, one sees that what we call disease also falls into the same category. For disease represents the necessary outcome of a disturbance, however introduced, into the course of metabolism, which diverts it from the "normal" channels. Pathology has long recognised that the explanation and the consequent control of disease lies, ultimately, in the correct appreciation of the cellular reactions as the result of their experimental study. We cannot pride ourselves on the advances that have been made in the study of plant pathology as yet. Our remedies are commonly of the crudest kind, and we have only recently begun to take serious count of the facts of organisation in the scientific attempt to breed races of plants immune from the attack of certain diseases. The results that have already been obtained, both abroad and by Biffen and others in this country, are full of hope at the present time. The study of the causes of immunity along scientific lines ought assuredly to form a fruitful field of investigation in the near future.

From what we already know it seems clear that the proximate causes of immunity may be diverse in character, and may consist in very different reactions in different cases. It may be that the response becomes expressed in a modification of the carbohydrate metabolism, leading to the formation of an excluding layer of cork; or it may lie in the direction of those substances, as yet so little understood, the anti-toxins; or, again, it may be due to still other and even less apparent causes. But whatever the true nature of the response, it will have to be investigated for individual cases, and its secrets will only be unlocked when the chemical and physical processes involved in its operation are understood.

In making these remarks I dare say I may be accused of putting forward an impossible ideal, or at any rate one that is impracticable of attainment. I am not very much concerned about that. Progress is only to be made by trying to penetrate further than we can at present see, and I believe we have gained enough insight into the chemistry and physics of the living processes to warrant us in hoping that we shall penetrate a good deal deeper still. But if we are to ever unravel the tangle, it can only be by applying such methods as have been successful in dealing with material things elsewhere.

For the problems that rise up before us are seen, as we become able to get at close quarters with them, to resolve themselves more and more into questions of chemistry and physics. I believe that it is only by the help of these elder branches of science that the accurate formulation, to say nothing of the final solution, of the problems will be achieved. A recent writer has suggested that life is not the cause of the reactions underlying the phenomena of life. Nevertheless the reactions that go on in the living body are obviously guided as to the particular directions they take by the apparatus or mechanism of the individual organism. When the conditions for the manifestation of life, and all that it implies, are satisfied, what will be produced depends partly on the structure of the apparatus itself (*i.e.*, on the hereditary organisation), partly on the nature of the substances fed into the apparatus, and finally on the physical conditions under which it is working. It is probably along the last two lines that investigation will continue to be pursued with more immediate profit; but the goal will not be finally reached until we have solved the problem as to the nature of organisation itself.

SECTION L.

EDUCATIONAL SCIENCE.

OPENING ADDRESS BY SIR PHILIP MAGNUS, B.Sc., B.A., M.P., PRESIDENT OF THE SECTION.

The Application of Scientific Method to Educational Problems.

NOTWITHSTANDING the fact that the greater part of my life has been spent in educational work, in teaching, in examining, in organisation, and in the investigation of foreign systems of instruction, I have experienced considerable difficulty in selecting, from the large number of subjects that crowd upon me, a suitable one on which to address you as President of a Section of the British Association devoted to educational science.

At the outset I am troubled by the title of the section over which I have the honour to preside. I cannot refrain from asking myself the question, Is there an educational Science, and if so, what is its scope and on what foundations does it rest? The object of the British Association is the advancement of Science, and year by year new facts are recorded in different branches of inquiry, on which fresh conclusions can be based. The progress of past years, whether in Chemistry, Physics or Biology, can be stated. Can the same be said, and in the same sense, of Education? It is true that the area of educational influence is being constantly extended. Schools of every type and grade are multiplied, but is there any corresponding advance in our knowledge of the principles that should govern and determine our educational efforts, or which can justify us in describing such knowledge as Science? If we take Science to mean, as commonly understood, organised knowledge, and if we are to test the claim of any body of facts and principles to be regarded as Science by the ability to predict, which the knowledge of those facts and principles confers, can we say that there exists an organised and orderly arrangement of educational truths, or that we can logically, by any causative sequence, connect training and character either in the individual or in the nation? Can we indicate, with any approach to certainty, the effects on either the one or the other of any particular scheme of education which may be provided? It is very doubtful whether we can say that educational science is yet sufficiently advanced to satisfy these tests.

But although education may not yet fulfil all the conditions which justify its claim to be regarded as a science, we are able to affirm that the methods of science, applicable to investigations in other branches of knowledge, are equally applicable to the elucidation of educational problems. To have reached this position is to have made some progress. For we now see that if we are ever to succeed in arriving at fixed principles for guidance in determining the many difficult and intricate questions which arise in connection with the provision of a national system of education, or the solution of educational problems, we must proceed by the same methods of logical inquiry as we should adopt in investigating any other subject-matter.

In order to bring Education within the range of subjects which should occupy a place in the work of this Association, our first efforts should be directed towards obtaining a sufficient body of information from all available sources, past and present, to afford data for the comparisons on which our conclusions may be based. One of the five articles of what is known as the Japanese Imperial Oath states, "Knowledge shall be sought for throughout the whole world, so that the welfare of the Empire may be promoted"; and it may certainly be said that, as the welfare of our own Empire is largely dependent on educational progress, a wide knowledge of matters connected with Education is indispensable, if we are to make advances with any feeling of certainty that we are moving on the right lines.

There can be no doubt that of late years we have acquired a mass of valuable information on all sorts of educational questions. We are greatly indebted for much of our knowledge of what is being done in foreign countries to the Reports of different Commissions, and more particularly to those special reports issued from the Board of Education, first under the direction of my predecessor in this Chair, Prof. Sadler, and latterly of his successor at the Board, Dr. Heath. But much of the information we have obtained is still awaiting the hand of the scientific worker to be properly coordinated and arranged. A careful collation of facts is indispensable if we are to deduce from them useful principles for our guidance, and unfortunately we in this country are too apt to rest content when we have provided the machinery for the acquisition of such facts without taking the necessary steps to compare, to coordinate, and to arrange them on some scientific principle for future use. Within the last week or two a Bill has passed through several stages in Parliament for requiring Local Authorities to undertake the medical inspection of school children, but, unless the medical inspectors throughout the country conduct their investigations on certain well-considered lines laid down for them by some Central Authority, we shall fail to obtain the necessary data to enable us to associate educational and physical conditions with a view to the improvement of the training given in our schools.[1] On the other hand, although I personally am sceptical as to the results, we have reason to believe that the inquiry recently undertaken into the methods adopted here and elsewhere for securing ethical as distinct from specifically religious training will be so conducted as to give us not only facts, but the means of inferring from those facts certain trustworthy conclusions.

The consideration of Education as a subject capable of scientific investigation is complicated by the fact that it necessarily involves a relation—the relation of the child or adult to his surroundings. It cannot be adequately considered apart from that relation. We may make a study of the conditions of the physical, intellectual, and ethical development of the child, but the knowledge so obtained is only useful to the educator when considered in connection with his environment and future needs, and the means to be adopted to enable him, as he grows in physical, intellectual, and moral strength, to obtain a mastery over the things external to him. Education must be so directed as to prove the proposition that "Knowledge is Power." It can only be scientifically treated when so considered. Education is imperfectly described when regarded as the means of drawing out and strengthening a child's faculties. It is more than this. Any practical definition takes into consideration the social and economic conditions in which the child is being trained, and the means of developing his faculties with a view to the attainment of certain ends.

It is in Germany that this fact has received the highest recognition and the widest application, and for this reason we have been accustomed to look to that country for guidance in the organisation of our schools. We have looked to Germany because we perceived that some relation had been there established between the teaching given to the people and their industrial and social needs; and further, that their success in commerce, in military and other pursuits was largely due to the training provided in their schools. Unmindful of the fact that Education is a relation, and that consequently the same system of education is not equally applicable to different conditions, there were many in this country who were only too ready to recommend the adoption of German methods in our own schools. Experience soon showed, however, that what may have been good for Germany did not apply to England, and that, in educational matters certainly, we do well to follow Emerson, who, when addressing his fellow citizens, declared: "We will walk on our own feet; we will work with our own hands, and we will speak our own minds." Still, the example of Germany and the detailed information which we have obtained as to her school organisation and methods of instruction have been serviceable to us.

Whilst all information on educational subjects is valuable, I am disposed to think that in our efforts to construct an educational science we may gain more by inquiring what has been effected in some of the newer countries. Wherever educational problems have been carefully considered and schemes have been introduced with the express intention and design of training citizens for the service of the State and of increasing knowledge with a view to such service, those schemes may be studied with advantage. Thus we may learn much from what is now being done in our Colonies. Their efforts are more in the nature of experiments. Our Colonies have been wise enough not to imitate too closely our own or any foreign system. They have started afresh, free from prejudice and traditions, and it is for this reason that I look forward with interest to the closer connection in educational matters of the Colonies with the mother country, and I believe that we shall gain much knowledge and valuable experience from the discussions of the Federal Conference which has recently been held in London, and which, I understand, is to be repeated a few years hence.

But valuable as are the facts, properly collated and systematically arranged, which a knowledge of British and foreign methods may afford us in dealing scientifically with any educational problem, it is essential that we should be able to test and to supplement the conclusions based on such knowledge, whenever it is possible, by direct experiments, applicable to the matter under investigation. We have not yet recognised the extent to which experiments in education, as in other branches of know-

[1] Since this was written the President of the Board of Education has stated in the House of Commons that "it was the intention of the Board, if the Bill now before Parliament passed, to establish a medical bureau, which would guide and advise the local authorities as to the nature of the work they would have to do under the Act."

ledge, may help in enabling us to build up an educational science. Some years since there was established in Brussels an *École modèle* in which educational experiments were tried. I visited the school in the year 1880, and I could easily point to many improvements in primary education which found their way from that school through the schools of Belgium and France to our own country, and, indeed, to other parts of the world. From a special Report on Schools in the North of Europe, recently published by the Board of Education, we learn that in Sweden the value of such experiments is fully recognised. We are told that in that country "it was early felt that the uniformity in State Schools was of so strict a kind that some special provision should be made for carrying out educational experiments," and experiments in many directions have been made, mainly in private schools, which receive, however, special subventions from the State. We gather from the same Report that the State regards the money as well earned "if the school occasionally originates new methods from which the schools can derive profit." I venture to think that experimental schools might with advantage be organised under the direction of some of our larger local authorities. The children would certainly not suffer by being made the subjects of such experiments. The intelligent teaching which they would receive—for it is only the most capable teachers who should be trusted with such experiments—would more than compensate for any diminution in the amount of knowledge which the children might acquire, and indeed such experimental schools might be conducted under conditions which would ensure sound instruction. Many improved methods of teaching are constantly advocated, but fail to be adopted because there is no opportunity of giving them a fair trial. As a general rule it is only by the effort of private individuals or associations that changes in system are effected, and teachers are enabled to escape from the old grooves on to new lines of educational thought and practice. It is not difficult to refer to many successful experiments. The general introduction into our schools of manual training was the direct result of experiments carefully arranged and conducted by a Joint Committee of the City Guilds and the late London School Board. Experiments in the methods of teaching Physical Science, Chemistry, and Geometry have been tried, with results that have led to changes which have revolutionised the teaching of those subjects. The age at which the study of Latin should be commenced with a view to the general education of the scholar has been the subject of frequent trial. I would like to see such experiments more systematically organised, and I am quite certain that the curriculum of our rural and of our urban schools would soon undergo very considerable changes, if the suggestions of competent authorities could receive a fair trial under conditions that would leave no manner of doubt as to the character of the results.

It would seem, therefore, that if our knowledge of the facts and principles of education is not yet sufficiently organised to enable us to determine *a priori* the effect on individual or national character of any suggested changes, education is a subject that may be studied and improved by the application to it of scientific method, by accurate observation of what is going on around us, and by experiments thoughtfully conducted. This is the justification of the inclusion of the subject among those that occupy the attention of a separate section of this Association. Our aim here should be to apply to educational problems the well-known canons of scientific inquiry; and, seeing that the conditions under which alone any investigation can be conducted are in themselves both numerous and complicated, it is essential that we should endeavour to liberate, as far as possible, the discussion of the subject from all political considerations. Such investigations are necessarily difficult. We have to determine both statically and dynamically the physical, mental, and moral condition of the child in relation to his activities and surroundings, and we have further to discover how he is influenced by them, how he can affect them, and the character of the training which will best enable him to utilise his experiences, and to add something to the knowledge of to-day for future service.

Notwithstanding the undoubted progress which we have made, it cannot be denied that in this country there still exists a large amount of educational unrest, of dissatisfaction with the results of our efforts during the last thirty years. This is partly due to the fact that there is much loose thinking and uninformed expression of opinion on educational questions. No one knows so little as not to believe that his own opinion is worth as much as another's on matters relating to the education of the people. In this way statements, the value of which has not been tested, pass current as ascertained knowledge, and very often ill-considered legislation follows. In this country, too, the difficulty of breaking away from ancient modes of thought is a great drawback to educational progress. Suggestions for moderate changes, which have been most carefully considered, are deferred and decried if they depart, to any great extent, from established custom, and the objection to change very often rests on no historical foundation. Occasionally, too, the change proposed is itself only a reversion to a previous practice, which was rudely broken by thoughtless and unscientific reformers. The opposition which was so long raised to the establishment of local universities was largely due to want of knowledge on the subject; and certainly the creation, some seventy years ago, of a teaching University in London was actually hindered through a mere prejudice, which broader views as to the real purposes of University teaching and fuller information on the course of University development would have removed.

There never was a time perhaps when it was more necessary than now that education should be regarded dispassionately, apart from political bias, as a matter of vital interest to the people as a whole. Education nowadays is a question which affects not only the life of a few privileged, selected persons, but of the entire body of citizens. The progress that has been made during the last few years in nationalising our education has been very rapid. It may be that it has been too rapid, that sufficient thought has not been given to the altered social and industrial conditions which have to be considered. We have witnessed a strong desire and a successful effort to multiply Secondary and Technical Schools and to open more widely the portals of our Universities. The object of the desire is good in itself. As the people grow in knowledge the demand for higher education will increase; but the serious question to be considered is whether the kind of education which was supplied in schools, founded centuries ago to meet requirements very different from our own, is equally well adapted to the conditions which have arisen in a state of society having other needs and new ideals. Very rightly our students in training for the profession of teachers are expected to study the writings of Locke, Rousseau, Milton, Montaigne, and others; but many are apt to overlook the fact that these writers had in view a different kind of education from that in which modern teachers are engaged, and that their suggestions, excellent as many of them are, were mainly applicable to the instruction to be given by a tutor to his private pupil, and had little or no reference to the teaching of the children of the people in schools expressly organised for the education of the many. Only recently have we come to realise that a democratic system of education, a system intended to provide an intellectual and moral training for all citizens of the State, and so organised that, apart from any consideration of social position or pecuniary means, it affords facilities for the full development of capacity and skill wherever they may occur, must be essentially different in its aims and methods from that under which many of us now living have been trained. It has also been brought home to us that the marvellous changes in our environment, in the conditions under which we live and work, whether in the field, the factory, or the office, have necessitated corresponding changes in the education to be provided as a preparation for the several different pursuits in which the people generally are occupied. Yet, notwithstanding these great forces which have broken in upon and disturbed our former ideals, forces the strength and far-reaching effects of which we readily admit, we still hesitate to face the newly arisen circumstances and to adapt our educational work to its vastly extended area of operation and to the altered conditions and requirements of modern life.

When I say we hesitate to face the existing circumstances I do not wish to be misunderstood. As a fact, changes are continually being discussed, and are from time to time introduced into our schools. But such modifications of our existing methods are generally isolated and detached, and have little reference to the more comprehensive measures of reform which are now needed to bring our teaching into closer relation with the changed conditions of existence consequent on the alterations that have taken place in our social life and surroundings.

Four years ago, it will be remembered, a committee of this section was appointed to consider and to report upon the "Courses of Experimental, Observational, and Practical Studies most suitable for Elementary Schools." That committee, of which I had the honour to be chairman, presented a report to this section at the meeting of the Association held last year at York. The general conclusion at which they arrived was that "the intellectual and moral training, and indeed to some extent the physical training, of boys and girls between the ages of seven and fourteen would be greatly improved if active and constructive work on the part of the children were largely substituted for ordinary class teaching, and if much of the present instruction were made to arise incidentally out of, and to be centred around, such work." It is too early, perhaps, to expect that the suggestions made in that report should have borne fruit, but I refer to it because it illustrates the difference between the spasmodic reforms which from time to time are adopted, under pressure from bodies of well-meaning representatives of special interests, and the well-considered changes recommended by a committee of men and women of educational experience who have carefully tested the conclusions at which they have arrived.

There can be no doubt that, as regards our elementary education, there is very general dissatisfaction with its results, since it was first nationalised thirty-seven years ago. Our merchants and manufacturers and employers of labour, our teachers in secondary and technical schools all join in the chorus of complaint. They tell us that the children have gained very little useful knowledge and still less power of applying it. There is enough in this general expression of discontent to give us pause and to make us seek for a rational explanation of our comparative failure. The inadequacy of the results attained to the money and effort that have been expended is in no way due to any want of zeal or ability on the part of the teachers, or of energy on the part of school boards or local authorities. They have all discharged the duties which were imposed upon them. It is due rather to the fact that the problem has been imperfectly understood, that our controlling authorities have had only a vague and indistinct idea of the aim and end of the important work which they were charged to administer. If we look back upon the history of elementary education in this country since 1870, we cannot fail to realise how much its progress has been retarded by errors of administration due very largely to the want of scientific method in its direction. It is painful to reflect, for instance, on the waste of time and effort, and on the false impressions produced as to the real aim and end of education, owing to the system of payment on results, which dominated for so many years a large part of our educational system. We must remember that it is only within the last few decades that education has been brought within reach of all classes of the population. Previously it was for the few; for those who could pay high fees; for those who were training for professional life, whether for the Church, the Army, the Navy, Law, or Medicine, or for the higher duties of citizen life. This had been the case for centuries, not only in this country, but in nearly all parts of the civilised world. If we read the history of education in ancient Greece or Rome, or mediæval Europe, we shall see that popular education, as now understood, was unknown. All that was written about education applied to the few who got it, and not to the great mass of the people engaged in pursuits altogether apart from those in which the privileged classes were employed. Trade and manual work were despised, and were considered degrading and unworthy of the dignity of a gentleman. I need scarcely say that these social ideas are no longer held. The fabric of society is changed, and we have to ask ourselves whether the methods of education have been similarly changed, whether they have been wisely and carefully adapted to the new order of things. What is it that has really happened? Is it not true that we have annexed the methods and subjects of teaching which had been employed during many centuries in the training of the few and applied them to the education of the people as a whole—to those who are engaged in the very callings which were more or less contemned? Surely it is so, and the results are all too manifest. We have applied the principles and methods of the secondary education of the Middle Ages to our new wants, to the training of the people for other duties than those to which such education was considered applicable, and it is only within the last few years that we have begun to see the error of our ways. In the report of your committee, to which I have referred, it is pointed out that the problem of primary education has been complicated by the introduction of the methods which for many years prevailed in secondary schools, and at a meeting of the National Education Association, held only a few weeks since, it was truly said: "In this country secondary education preceded primary by several centuries, and so the nation now finds itself with the aristocratic cart attempting to draw the democratic horse."

Let it not be supposed that in the days not so far distant, yet stretching back into the remote past, the people as a whole were uneducated. This was not so. But we have to widen the meaning of education to include the special training which the people then received—an education that was acquired without even the use of books. It cannot for one moment be said that the artisans, the mechanics, the farm hands, male and female, were wholly uneducated in those far-off days. In one sense possibly they were. Very few of them could read or write. But from earliest childhood they had received a kind of training the want of which their descendants have sadly felt in the cloistered seclusion of the modern elementary school. They were brought face to face with Nature. They learned the practical lessons of experience; and as they grew up their trade apprenticeship was an education which we have been trying vainly to reproduce. They gained some knowledge of the arts and sciences, as then understood, underlying their work. Their contact with their surroundings made them thoughtful and resourceful, for Nature is the most exacting and merciless of teachers. The difficulties they had to overcome compelled them to think, and of all occupations none is more difficult. They were constantly putting forth energy, adapting means to ends, and engaging in practical research. In the field, in the workshop, and in their own homes boys and girls acquired knowledge by personal experience. Their outlook was broad. They learned by doing. It is true that nearly all their occupations were manual, but Emerson has told us, "Manual training is the study of the external world."

Compare for a moment this training with that provided in a public elementary school, and you cannot be surprised to find that our artificial teaching has failed in its results, that our young people have gained very little practical knowledge, and that what they have gained they are unable to apply; that they lack initiative and too often the ability to use books for their own guidance, or the desire to read for self-improvement. We seem to have erred in neglecting to utilise practical pursuits as the basis of education, and in failing to build upon them and to evolve from them the mental discipline and knowledge that would have proved valuable to the child in any subsequent occupation or as a basis for future attainments. We have made the mistake of arresting, by means of an artificial literary training, the spontaneous development of activity, which begins in earliest infancy and continues to strengthen as the child is brought into ever closer contact with his natural surroundings. We have provided an education for our boys which might have been suitable for clerks; and, what is worse, we have gone some way, although we have happily cried a halt, to make our girls into "ladies," and we have run some risk of failing to produce women.

If we are to correct the errors into which we have drifted, if we are to avert the consequences that must overtake us through having equipped our children for their life-struggle with implements unfitted for their use, we must consider afresh the fundamental ideas on which a system of elementary education should be based. Instead of excluding the child from contact with the outer world we must bring him into close relationship with his surroundings. It was given to man to have dominion over all other created things, but he must first know them. It is in early years that such knowledge is most rapidly acquired, and it is in gaining it that the child's intellectual activities are most surely quickened.

It is unfortunate that we failed to realise this great function of Elementary Education when we first essayed to construct for ourselves a national system. The three R's, and much more than that, are essential and incidental parts of Elementary Education. But what is needed is a *Leitmotif*—a fundamental idea underlying all our efforts and dominating all our practice, and I venture to think that that idea is found in basing our primary education on practical pursuits, on the knowledge gained from actual things, whether in the Field, the Workshop, or the Home.

Instead of fetching our ideas as to the training to be given in the people's schools from that provided in our old grammar schools, we should look to the occupations in which the great mass of the population of all countries are necessarily engaged, and endeavour to construct thereon a system with all such additions and improvements as may be needed to adapt it to the varied requirements of modern life. By this process—one of simple evolution adjusted to everyday needs—a national system of education might be built up fitted for the nation as a whole—a system founded on ideas very different from those which, through many centuries, have governed the teaching in our schools. In the practical pursuits connected with the Field, the Workshop, and the Home, and in the elementary teaching of science and letters incidental thereto, we might lay the foundation of a rational system of primary education.

These three objects—the Field, the Workshop, and the Home—should be the pivots on which the scheme of instruction should be fixed, the central thoughts determining the character of the teaching to be given in rural and urban schools for boys and girls. It was Herbart who insisted on the importance of creating a sort of centre around which school studies should be grouped with a view to giving unity and interest to the subjects of instruction. I have elsewhere shown how a complete system of primary education may be evolved from the practical lessons to be learned in connection with out-door pursuits, with workshop exercises and with the domestic arts, and how, by means of such lessons, the child's interest may be excited and maintained in the ordinary subjects of school instruction, in English, arithmetic, elementary science, and drawing. In the proposals I am now advocating I am not suggesting any narrow or restricted curriculum. On the contrary, I believe that, by widening the child's outlook, by closely associating school work with familiar objects, you will accelerate his mental development and quicken his power of acquiring knowledge. I would strongly urge, however, that the child should receive less formal teaching, that opportunities for self-instruction, through out-door pursuits, or manual exercises, or the free use of books, should be increased, so that as far as possible the teacher should keep in view the process by which in infancy and in early life the child's intelligence is so rapidly and marvellously stimulated. Already we have discovered that our unscientific attitude towards primary education has caused us to overlook the essential difference between the requirements of country and of town life, and the training proper to boys and girls. Our mechanical methods of instruction, as laid down in codes, make for uniformity rather than diversity, and we are only now endeavouring, by piecemeal changes, to bring our teaching somewhat more closely into relation with existing needs. But the inherent defect of our system is that we have started at the wrong end, and, instead of evolving our teaching from the things with which the child is already familiar, and in which he is likely to find his life's work, we have taken him away from those surroundings and placed him in strange and artificial conditions, in which his education seems to have no necessary connection with the realities of life.

The problem of primary education is to teach by practical methods the elements of letters and of science, the art of accurate expression, the ability to think and to control the will; and the ordinary school lessons should be such as lead to the clear apprehension of the processes that bring the child into intimate relation with the world in which he moves. During the last few years the importance of such teaching has dimly dawned upon our educational authorities, but, instead of being regarded as essential, it has been treated as a sort of *extra* to be added to a literary curriculum, already overcrowded. What is known as manual training is to some extent encouraged in our schools, but it forms no part of the child's continuous education. It is still hampered with conditions inconsistent with its proper place in the curriculum, and is uncoordinated with other subjects of instruction. Moreover, no connecting link has yet been forged between the teaching of the Kindergarten and workshop practice in the school. We speak of lessons in manual training as something apart from the school instruction, as something outside the school course, on the teaching of which special grants are paid. Twenty or thirty years ago people used to talk about "teaching technical education," and from this unscientific way of treating the close connection that should exist between hand-work and brain-work our authorities have not yet freed themselves.

It is true we have long since passed that stage when it was thought that the object of instruction in the use of tools was to make carpenters or joiners; but, judging from a report recently issued by the Board of Education, it would seem that it is still thought that the object of cookery lessons to children of twelve to fourteen years of age is the training of professional cooks. Until the Board's inspectors can be brought to realise that the aim and purpose of practical instruction in primary schools, whether in cookery or in other subjects, is to train the intelligence through familiar occupations, to show how scientific method may be usefully applied in ordinary pursuits, and how valuable manipulative skill may thus be incidentally acquired, it does not seem to me that they themselves have learned the most elementary principles of their own profession. An anonymous teacher, writing some weeks since in the *Morning Post*, said: "The cookery class can be made an invaluable mental and moral training ground for the pupils, the most stimulating part of primary education. It teaches unforgettable lessons of cleanliness and order, of quickness and deftness of movements. The use of the weights and scales demands accuracy and carefulness, and the raw materials punish slovenliness or want of attention with a thoroughness which the most severe of schoolmasters might hesitate to use. Practical lessons in chemistry should form an important feature of each class. . . . The action of heat and moisture on grains of rice provides an interesting lesson on the bursting of starch cells, and the children's imagination is awakened by watching the hard isolated atoms floating in milk change slowly to the creamy softness of a properly made rice pudding. The miraculous change in the oily white of egg when it is beaten into a mountain of snowy whiteness gives them interest in the action of air and its use in cookery."

Can the teaching of grammar or the analysis of sentences provide lessons of equal value in quickening the intelligence of young children?

I must add one word before passing from this suggestive illustration of the value of scientific method in the treatment of educational questions. We live in a democratic age, and any proposed reform in the teaching of our primary schools must be tested by the requirement that the revised curriculum shall be such as will provide not only the most suitable preparatory training for the occupations in which four-fifths of the children will be subsequently engaged, but will, at the same time, enable them or some of them to pass without any breach of continuity from the primary to the secondary school. There must be no class distinctions separating the public elementary from the State-aided secondary school. The reform I have suggested is unaffected by such criticism. The practical training I have advocated, whether founded on object-lessons furnished by the Field, the Workshop, or the Home, would prove the most suitable for developing the child's intelligence and aptitudes and for enabling him to derive the utmost advantage from attendance at any one of the different types of secondary schools best fitted for his ascertained abilities and knowledge. The bent of the child's intellect would be fully determined before the age when the earliest specialisation would be desirable. No scheme of instruction for primary schools can be regarded as satisfactory which is not so arranged that, whilst providing the most suitable teaching for children who perforce must enter some wage-earning pursuit at the age of fourteen, or at the close of their elementary school course, shall at the same time afford a sound and satisfactory basis on which secondary and higher education may be built. And I hold the opinion, in which I am sure all teachers will concur, that a scheme of primary education pervaded by the spirit of the Kindergarten which, by practical exercises, encourages observation and develops the reasoning faculties, and creates in the pupil an understanding of the use of books, would form a fitting foundation for either a literary or a scientific training in a secondary school.

I have purposely chosen to illustrate the main subject of this address by reference to defects in our primary instruction, because the success of our entire system of education will be found, year by year, to depend more and more upon the results of the training given in our public elementary schools. We have scarcely yet begun to realise the social and political effects of the momentous changes in our national life, consequent on the first steps which were taken less than forty years ago to provide full facilities under State control and local management for the education of the people.

At present all sorts of ideas are afloat which have to be carefully and scientifically considered. The working classes have to be further and somewhat differently educated, in order that they may better understand their own wants and how they are to be satisfied. We have placed vast powers in the hands of local bodies, popularly elected, powers not only of administration, for which they are well adapted, but powers of determining to a very great extent, by the free use of the rates, the kind of instruction to be given in our schools, and the qualifications of the teachers to impart it. Moreover, these local bodies have shown, in many instances, a distrust of expert advice and a desire to act independently as elected representatives of the people, which cannot fail for some time at least to lead to waste of effort and of means. It was said years ago, when the centre of our political forces received a marked displacement, that we must educate our masters. Our masters now, both in politics and education, are the people, and it is only, I believe, by improving their education that we can enable them to understand the essential difficulties of the problems which they are expected to solve, and can induce them to rely, to a greater extent than they do at present, on the results of the application to such problems of scientific method, founded on the fullest information obtainable from historical and contemporary sources.

I might have illustrated my subject by reference to the acknowledged chaotic condition of our secondary education. In the report of the Board of Education published in December last we read: "While the development of secondary education is the most important question of the present day, and is the pivot of the whole education as it affects the efficiency, intelligence, and well-being of the nation, yet its present position may be described as 'chaos.'" The "chaos" by which the present position of our secondary education is here described is intimately connected with the questions relating to primary education, which I have been engaged in considering. If we construct a system of primary education which serves equally for children of all classes, apart from social conditions—a system educationally sound, both as a preparation for immediate wage-earning pursuits and for more advanced and somewhat more specialised training in a secondary school—many of the difficulties which confront the Board of Education, and which are largely of an administrative order, would disappear. The difficulties are in part dependent on the question of curriculum, to the discussion of which a day will be devoted during the present meeting.

University education in this country, and indeed in other countries, has also suffered much from the hands of the unscientific reformer. In Germany, owing to many causes, the higher education has made considerable advances during the past century; but, even in that country, a more critical study of the development of University education and a truer recognition of the twofold function of a University might have prevented the early separation in distinct institutions and under separate regulations of the higher technical from University instruction. Only within recent years has France retraced her steps and returned to the University ideal of seven centuries ago. But perhaps the climax of unscientific thinking was reached in the scheme, happily abandoned, of founding a new University in Dublin on the lines suggested by Mr. Bryce in his now famous speech of January last.

Our conception of the functions of a University has undergone many violent changes. Between the ideal of the University of London prior to its reorganisation and that of a mediæval University, in which students were never plucked, obtaining their degrees whether they did their work well or badly, there have been many variations; but I think it may be said that, recently at any rate, we have come to realise the fact that our Universities, to fulfil their great purpose, must be schools for the preparation of students for the discharge of the higher duties of citizenship and professional life, and Institutions for the prosecution of research, with a view to the promotion of learning in all its branches, and that examinations for degrees, necessary, as they undoubtedly are, as tests of the extent of a student's acquired knowledge, must be regarded as subordinate to these two great functions.

I will not detain you longer. I have endeavoured to show under what limitations education may lay claim to be included among the sciences, and how a knowledge of the history of education and the application of the methods of scientific inquiry may help in enabling us to solve many of the intricate and complicated questions which are involved in the establishment on a firm foundation of a national system of education. I have taken my illustrations mainly from the reform of elementary, or, as I prefer to call it, primary education, and I have sought to indicate some of the errors into which we may fall when we fail to apply to the consideration of the problem the same principles of inductive inquiry as are employed in all investigations for the attainment of Truth.

I believe that this Section of the British Association has the opportunity of rendering a great service to the State. Numerous educational societies exist, in which questions of importance are discussed, and all, perhaps, do useful work. But none is so detached from separate and special interests; none stands so essentially apart from all political considerations; none is so competent to discuss educational problems from the purely scientific standpoint as are the members of this Association. If, in the remarks I have offered, somewhat hastily prepared under the pressure of many different kinds of work, I have contributed anything to the solution of a problem the difficulty and national importance of which all will admit, I shall feel that I have not been altogether unworthy of the honour of occupying this Chair.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

LIVERPOOL.—Mr. Percy E. Newbury has been appointed professor of Egyptology in the University.

LONDON.—University College:—With the assistance of the Chadwick trustees, arrangements have been completed to hold a new course on school hygiene, including lectures, demonstrations, and practical work, beginning on October 16. The course will be given by Prof. Henry Kenwood and Dr. H. Meredith Richards. It is designed to meet the requirements of school teachers, school lecturers, and those qualifying to become school inspectors and school medical officers. A certificate of proficiency will be granted to those who qualify themselves.