power of yeast, as Pasteur supposed, actually tended to stimulate it.

Undoubtedly the most striking advance in connection with fermentation is Buchner's famous discovery that the direct cause of the fermentative power of yeast is an enzyme present in the cell. This at once destroyed all theories connecting fermentative power with the vital activity of the cell. The enzyme has been termed zymase, and its behaviour, which in many respects differs from that of other enzymes, has been studied very fully both by Buchner himself and also by Harden, whose results are of a very remarkable character.

When yeast juice, which contains active zymase, is filtered through a Chamberland gelatine filter, it is separated into two portions, one of which remains on the filter, whilst the other passes through. Apart, neither portion has any fermentative power; when united they ferment sugar. The filtrate still retains the power of activating the residue after it has been boiled; it has been named the co-enzyme. The part retained on the filter is destroyed by boiling; it is considered to be the enzyme.

Further experiments showed that dilute solutions of sodium or potassium phosphate have a marked stimulating effect on the activity of zymase, and proof has been afforded that a compound of sugar and phosphoric acid is formed when such addition is made. At the same time, a part of the sugar is decomposed to alcohol and carbon dioxide. An enzyme, appropriately named hexosephosphatase, is present in yeast juice, and serves to break down the compound of sugar and phosphate into its components. Such facts as these have introduced altogether new conceptions into the knowledge of enzymes.

Without going into greater detail in so complex a subject, Dr. Harden's explanation of the fermentation process may be summed up somewhat as follows.

Enzyme and co-enzyme act in unison on a mixture of hexose sugar and phosphate; one half of the sugar is decomposed into alcohol and carbon dioxide, and the other half combines with the phosphate, forming hexosephosphate. The phosphate is thus for the time being put out of action, but the hexosephosphatase enzyme comes into work and resolves it into free phosphate and free sugar, when the cycle of changes begins anew. The speed of fermentation is regulated by the activity of the hexosephosphatase. Dr. Harden has calculated that with ordinary brewer's yeast at 25° C. the whole of the phosphorus of its cell goes through this cycle twice in every five minutes!

It is well known that, besides ordinary ethyl alcohol, small quantities of other higher alcohols are formed during fermentation, particularly under the working conditions of a distillery. The explanation of the formation of these "fusel oil" constituents has been long outstanding, but quite recently Ehrlich has proved beyond doubt that they arise from the action of yeast on the amino-acids ordinarily present in fermentable liquors. These alcohols are physiologically of great importance as stimulants and excitants of protoplasmic activity. Their presence, even in the minutest quantity, has considerable bearing on questions of flavour, so that technically the proper understanding of their mode of formation is a matter of great importance. Ehrlich's researches have gone far in this direction, and their application in practice is bound to lead to valuable results. It is not improbable that many of the subtle flavouring materials met with in plants may originate from amino-acids in the same manner.

Much has been done in studying the influence of traces of other substances on yeast, since the final character of the beer depends to a large extent on the fermentation being normal. As showing how sensitive the living cell is to stimulus, the effect of zinc on the growth of the mould fungus, *Aspergillus niger*, may be cited. Almost inconceivably small amounts of this element—a dilution of 1 part in 50 millions—are capable of exercising a noticeable effect in favouring growth. Copper in like dilution is known to have a poisonous effect on bacteria, and it is evident that the brewer must use the greatest care in the selection of his vessels.

In addition to the thirteen elements which are generally stated to be essential to plant life, many others are found in plants in very small quantities. The tendency has been, for the most part, to regard these as accidentally acquired, and not essential. Latterly the point of view is changing, and there is evidence that some at least of the elements present in minimal quantities play a very important part.

Sufficient has been said to indicate how closely science and brewing are connected, and how many problems still await solution.

EDUCATIONAL CONFERENCES CONSIDERED IN RELATION TO SCIENCE IN PUBLIC SCHOOLS.

I.

THE end of the second week in January marks the close of a series of conferences which are annually attended by teachers. The majority of these conferences are concerned, in the main, with topics which have only a remote connection with the subjects usually connoted by "science." An exception to this statement must, of course, be made in the case of the proceedings of the Association of Science Masters in Public Schools, which have a strong and beneficial influence on the early training of men who may be expected to take leading positions, not only in the university, but in the country generally. It is owing in part to the realisation of this influence, in part to the sensitiveness and ready response to stimuli of the audience, in part to good management of the society, that the association has been able to secure, year by year, an address from a man of real eminence, and this time special importance was given to the meeting by the fact that Sir Joseph Thomson had accepted the office of president. His address is reproduced elsewhere in this journal; we may here testify to the obvious enjoyment which its delivery gave to the audience, and ask the serious attention of headmasters to the weighty remarks concerning neglect of the German language.

The first paper was contributed by Mr. M. D. Hill (Eton), who has been led by his own experience to doubt the necessity, or even the wisdom, of previous training in chemistry and physics for young biologists. In the discussion the weight of opinion was clearly in favour of insistence on such training. Mr. E. I. Lewis (Oundle), in the next paper, argued that plant biology should be taught in every secondary school. It was a subject the interest and value of which increased throughout life. For junior pupils the subject of plant life affords a preparatory study full of suggestion for the after-study of chemistry, and it does not demand a special technical knowledge on the part of the teacher. The work can consist almost entirely of observation and experiment in the class-room and out of doors; it abounds in examples of comparative method. Another paper dealing with the sequence of subjects was read by Mr. C. E. Ashford (Royal Naval College, Dartmouth), who discussed the place of electrostatics in a school course of electricity. Mr. Ashford began by excluding from the discussion the case of those students of eighteen years and above who are studying as "science specialists" with good mathematical equipment, and invited consideration of the average boys about fifteen years old. He supported the theory which deprecates teaching subjects for their artificial "discipline," and attaches importance to the value of the "content" or subject-matter. On these grounds, and by reason of the great interest evoked in the inquiring mind of boyhood by the everyday phenomena of current electricity witnessed in modern life, it seemed good to begin with the effects of the current, and to postpone electrostatics until some idea of Ohm's law had been obtained. One unfortunate result of insistence on preliminary electrostatics had been unduly to postpone the study of electricity in those practical applications which appeal to the ordinary boy.

Mr. Ashford had been convinced by his experience at Harrow of the soundness of these propositions, and he proceeded to sketch a plan of teaching in accordance therewith. He showed by demonstrations with the current from the lighting supply, and with commercial instruments, how readily electrostatics could be made to follow the current work, and directed attention to the fact that success did not depend on the weather. Prof. Worthington criticised the details of Mr. Ashford's scheme, and advocated the older plan of taking electrostatics first. Mr. Sanderson, on the contrary, regarded the teaching of electrostatics to young boys as part of the system of too rapid driving of immature minds. Mr. B. M. Neville had tried the plan of taking voltaic electricity early, and leading the class to the problems of electrolysis. The behaviour of electrolytes suggested the existence of discrete quantities or particles of electricity, whence the boys obtained the concept of a measurable static charge. Upon this concept the structure of electrostatics could be built. Several speakers took part in the discussion, of which the outcome appeared to us to be as follows:—Current electricity is attractive to boys, and it takes an unusually poor teacher to deprive it of its interest; electrostatics can be made very interesting by a very good teacher. As a rule, the current work is far more successful than the other. A weak spot in past teaching has been the link between current and static effects; it was felt that Mr. Ashford's demonstration would help members to strengthen that link. Supposing the first difficulty of the transition to be mastered, several of the subsequent difficulties would be in the same position whichever approach had been adopted, except for the important consideration that the boys, by previous current work, had gained some familiarity with, and confidence in discussing, the problems of potential difference, &c. If boys had to leave school before finishing the electrical course, it was more profitable to them to have had the current electricity than the electrostatics, supposing time did not allow both to be taken.

The important question of the possibility of "formal training"—in the psychological sense of the term—was introduced by Mr. A. Vassall (Harrow) in a paper of remarkable lucidity. He advised science masters to study the recent work of psychologists, and took as a particular example the problem of formal training. He was led from his own experience to doubt the "faculty psychology" by which much of our present practice is usually justified, and found that general powers of observation are not necessarily increased by special training. A boy highly trained as an observer of chemical phenomena only develops his observational powers for chemical phenomena; there is no "overflow" which will increase his general powers of observation *except where there is some identity*. We must cultivate wide knowledge and interests, and pay more attention to the subject-matter of the curriculum and less to mental gymnastics. It seemed little less than a crime to use the lower or middle-school divisions simply as a training-ground for the later study of formal science when the majority of boys in the divisions are not proceeding to such later study. There is a marked tendency so to use them at present—*e.g.* there is too much weighing and mensuration, glass-working, and other chemical manipulation. These boys should work on broad lines—in physics at such things as the electric installation of a house; in chemistry at real experiments in breathing, burning, and decay, and other topics of wide application. The ideal curriculum would give the boy (1) as much knowledge of certain subjects as is required for culture and æsthetics; (2) of other subjects only so much as will not sap his intellectual self-reliance by their being attempted beyond his capacity; (3) a special knowledge, when possible, of a subject or subjects which will be useful to him in his after-life.

Prof. Armstrong stated that he accepted neither the experiments of the psychologists nor their inferences. He was convinced that types of mind differed more than was commonly recognised. An engineering, constructive mind could only be interested, for instance, in chemistry by appealing to it through topics closely in agreement with its own bias, *e.g.* through problems concerning the corrosion of metals. We must keep in mind man's experience through the ages. Man had been accustomed only to fight, to work, and to use his commercial instinct; and almost all modern education was alien to the experience of the race. We must make our instruction practical enough and simple enough for the majority of minds, and avoid the common tendency to postpone introducing a subject to too late in age. Dr. T. P. Nunn said that psychologists were quite alive to the present imperfections of their science, and all leaders in the subject advised caution in the application of recent inferences. The idea that the mind was like a photographic plate, the sensitiveness of which to all subjects could be increased by attention to one, was quite wrong. None the less, there was a development beyond a mere record of the actual thing observed. A student by observing gained self-reliance; he learned that he was capable of drawing a rational inference without depending on external authority; he learned that he must not be in a hurry if he wished to observe aright. These acquirements *did* increase a boy's power to behave duly and perform correctly in various situations. While listening to the discussion, which was well maintained, we could not help feeling that science teachers of all grades would gain much by a study of the papers on formal training which were read by Dr. Myers, Dr. Sleight, and Mr. C. L. Burt at the London County Council Conference of Teachers during the preceding week. They would gain a clearer idea of the present position of psychology, especially of the importance of the elements common to various mental performances.

We have brought together the above four subjects somewhat out of their order in the programme of the science masters' meeting, because they appear to manifest a common tendency. They all deal with the problem of suiting the subject-matter and the order of its presentation to the growing intelligence and developing interests of the boy. A few years ago the sequence of studies in the science side of the curriculum was determined by considerations of their logical order, and no one doubted that the logical order was the right one to follow. The new movement tends to make the logical order less dominant, and to determine the sequence rather by the psychological order of the boy's mental growth. We venture to put forward our personal impression of the direction in which, judged from the general attitude of the conferences, the science curriculum is evolving. Before doing so, we note with pleasure the action of the Headmasters' Conference with regard to Greek at entrance examinations, which was taken at the December (1911) meeting.

The headmasters of the largest public schools have definitely committed themselves to action which shall relieve the preparatory schools from teaching Greek to little boys. This makes it possible for a boy during his school life to follow such a course as the following:—(1) In the preparatory school a course of practical and seasonal nature-study with gradually increasing thoroughness and method; (2) in the lower school of the public school courses of, say, astronomy and plant physiology (as suggested in the paper by E. I. Lewis); (3) in the middle school a course of physics and chemistry, in which the utilitarian interest of the boys is utilised and made more and more scientific (*cf.* C. E. Ashford and A. Vassall), the quantitative side being well-developed, but not exclusively so. It is supposed that many boys will carry school science no further than this. For those who intend to pursue scientific study after school life there will be (4) a course of systematic study in physics, chemistry, and often biology. The work in this stage may best be treated by the method of the seminar, and considerable encouragement may well be given to the historical and philosophical aspects. It may even be wise to encourage theoretical speculation in order to inculcate habits of independent, self-reliant observation and reflection. Books of reference should be used, including French and German texts, and such works as Jevons's "Principles of Science" and Pearson's "Grammar of Science" should find readers. The suggestions for this stage appear to be in harmony with Sir Joseph Thomson's address.

The annual meeting of the Mathematical Association and the remainder of the science masters' programme will receive consideration in a subsequent article; but it may be stated at once that both meetings were well attended, and showed a growth in the area of effectiveness of the societies.

G. F. DANIELL.

THE PROTECTION OF ANCIENT MONUMENTS.

THE question of the protection of ancient monuments in this country has reached a new phase by a paper recently read by Sir Schomberg McDonell, secretary to the Office of Works, before the Society of Antiquaries. He referred to numerous cases, such as those of Stonehenge, the camp at Penmaenmawr, Meavy Bridge, Chichester Cross, the wall paintings of Tewkesbury Abbey, the proposed restoration of Carnarvon Castle, as instances