largely determined when the sequence of sciences is determined.

These and other similar existing conditions indicate, it seems to me, the fact that science teachers should be attempting to place the sciences in high schools upon a scientific basis. The amount of required science, the sequence of sciences, the science or sciences required, the sciences offered, etc., ought not to be a mere matter of chance or expediency as is so often the case at present; these things ought to be based upon accurate knowledge.

THE HIGH SCHOOL SCIENCE SITUATION.

BY W. L. EIKENBERRY,

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If it is true that periods of vigorous discussion are also likely to be periods of advance as well, we may hope to see early and definite results leading toward the solution of some of the problems of high school science. The variety of information developed in the present discussion is surprising. We have been told that there is among pupils a widespread distaste for science and that there is not; that the elections of sciences are increasing and that they are decreasing; that a certain subject will fail because the teachers are not prepared to teach it, while in another subject all the reported failures are due to the same cause and the subject will therefore ultimately succeed; that all the various sciences are but departments of one fundamental and all-embracing science, though as to which one shall lead there is an unfortunate difference of opinion. Different writers have different candidates for first place and singularly enough, in each case it seems to the science to which the writer has given closest study. Geography, physics, biology, and physiology are all candidates for the most prominent place on the ticket, and agriculture, domestic science, and chemistry are circulating petitions.

To an outsider there must appear great probability that we shall finally rediscover the fact that the divisions of the field of science are so poorly fenced off from each other that there is little difficulty in passing to any part of the field, regardless of the starting point.

The almost entire absence from the discussion of any tangible data bearing upon the questions at issue makes it hazardous to draw conclusions, but one may at least venture to suggest that

there is considerable uncertainty in the situation. The existence of this uncertainty is not wholly unavoidable. For instance, in the matter of number of elections of science in the high school it would appear that the obvious thing to do is to collect statistics of the actual number of elections in a series of representative schools for a number of years. The collection and analysis of such a series of facts as a method of investigating a question in pedagogy is peculiarly appropriate to science teachers since science demands the use of this method in the investigation of other problems.

The assertion of the general uncertainty of the science program is strengthened by the results of every investigation into the actual sequence of the sciences in high school curricula. Such investigations as those of Caldwell and of Hunter, published in *SCHOOL SCIENCE AND MATHEMATICS* last year, and the work of Miss Weckel which appears in the current number, show that almost any science may be taken in any year of the high school, and that by the aid of the elective system practically any imaginable sequence may be secured. In other words, the practice of the schools demonstrates that any one of the sciences as now presented can be taught in any year of the course.

For a concrete illustration of these facts we may refer to the work of Miss Weckel, since it is easily available. By referring to the summary in section four of her paper it will be noted that the selection of particular years by particular subjects is quite irregular, ranging from forty-three per cent to sixty-eight per cent, the highest being chemistry in the third year. Sixty-eight per cent does not indicate a very close agreement as to the place of a study in the program, but the actual selection is less even than this. If we discard astronomy, which is not commonly given, we find that all the other sciences find their largest selection, so far as those who make the course of study are concerned, in the first, second, and third years. Now it is evident that if the position of each science were decided by chance alone it would appear in each year one third of the time, or $33\frac{1}{3}\%$. The real selection then appears to be more accurately measured by the excess of percentage over $33\frac{1}{3}\%$. This is $12\frac{2}{3}\%$ in the lowest case and $34\frac{2}{3}\%$ in the highest. These figures certainly do not demonstrate that we have arrived at any commonly accepted arrangement of the course of study in science.

It is true that each year is characterized by a slight preference

for a particular science, but if we inquire regarding the reasons for this preference the replies are not satisfactory. It is explained in part by the historical reason that in the days when laboratories were introduced into the schools it appeared to be an economic necessity to place the subjects which demand expensive equipment in the years in which the classes are small. The relation of physics to mathematics is another of the factors which have determined present practice; there are many others. None of the reasons advanced are universally accepted. Mathematics certainly is a prerequisite for the work in physics as at present organized but it has been shown that it is possible to so organize the subject that it can be introduced earlier; on the other hand it is quite possible to justify an arrangement of the courses in physiography and biology such that they demand physics and chemistry as a prerequisite and profit very much from certain features of the work in mathematics. Whether such a modification of these subjects would be desirable is quite another question and one upon which we have little information. The proper sequence of the sciences in the course of study is a matter that cannot be decided wholly by a consideration of the theoretical relations of these fields of knowledge to each other but must rest mainly upon a determination of the needs of the pupils at different stages of their development and the suitability of various sorts of scientific material as instruments in advancing their development. We have scarcely begun to learn how to collect data upon this point.

The problem that lies before us is not that of a contest between two subjects for a certain position; the whole science curriculum of the high school is our problem. Since the work of the first year is necessarily fundamental as respects all that follows and since it is frequently required of all pupils it is being first attacked, and the discussion may confidently be expected to continue for some time. Just why such great apprehension should be occasioned, outside of text-book circles, by any proposals for experimentation in the first year is not clear. It is in fact easy to recall the time when all subjects competed for the coveted place in the later years. The principal contest at present is between physiography and general science. It is asserted that general science is foredoomed to failure because no unifying principle can be found. Prophecy is traditionally dangerous, and particularly so in this case. It is a bold man who will in the face of the unifying tendencies of all modern research deny the essential unity

of all science; those who are able to include the universe within a single science should not be the first to deny this unity.

The difficulty of securing teachers who are equipped to instruct in such a broad course does not seem insuperable. It may be recalled that many of the greatest names in contemporary American science are the names of men who not many years ago occupied not a chair of science but a whole bench, and in that capacity developed some of our best younger students of science and materially assisted in advancing the cause of science. True, our smaller colleges did not at that time offer much science, but they offered a good deal more than the present high school freshman is able to assimilate. There are plenty of men in similar positions in the smaller institutions at present. Such conditions may not make for efficiency in research, but the quality of the instruction is not seriously affected as is shown by the success of the students sent up to the greater institutions. There are also many teachers of broad scientific training and sympathies in high school faculties. In any case the state of unpreparedness can scarcely be worse than is asserted to be found in many of the sciences at present, and the need for broader training will be met as it arises by the institutions which prepare teachers of science.

The gist of the whole thing is that the matter cannot be settled by rhetoric. Facts ascertained by experiment are the final recourse. Upon purely theoretical grounds it would appear that there are certain logical advantages in an experiment which does not commit itself in advance to any particular field of science but draws its materials from all sciences with prejudice to none, as compared with an experiment which proceeds by adding extraneous material to a selected science already very well organized. In the latter case natural and unconscious conservatism throws the burden of proof upon the new material with consequent limitation of experimentation and prejudice of results. However, either method if pursued faithfully and scientifically should lead to the same result. What that result will be should be determined by experiment and not by prophecy. The introduction into courses in physiography of material from the other sciences, now commonly practiced, indicates that one of the results to date is a closer approximation of the two ideas.

Every form of educational experiment which has a rational basis and is conducted scientifically should be welcomed; those teachers who fail to record the results of their experiments and

to give to the world the data secured are thereby failing to assist in the solution of the problem. It may be hoped that the present tempest will be succeeded by a period whose dominant characteristic will be scientific investigation. Every class is a more or less instructive experiment and should be treated as such.

If such conditions as these shall exist we may hope that within a few years we shall be able to reach fairly definite conclusions upon several difficult problems. In the meantime we shall not be materially assisted by the polemics of those who are not teaching these subjects in the high schools, or of those who are doing so.

A WALL FORM OF BENDING APPARATUS.

By C. L. VESTAL,

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Most laboratory apparatus is made with the idea that it is to be assembled by the student. There are frequently cases, however, in which the value of the experiment would be greatly improved by relieving the student of this work. Especially is this true where the apparatus as set up on the table is unstable and very easily disarranged. This condition makes the student afraid that his experiment will not succeed and prevents him from concentrating his attention on the principle. It is therefore desirable in such cases to have a permanent piece of apparatus which can be rigidly attached to a table of its own and remain there. Then in working with it the boy has no fear that his apparatus will become dislodged and make him all the work of setting it up again.

A case in point is the working out of the laws of bending and of Hooke's law by means of bending. Most of the table apparatus for this purpose, which has come under the writer's notice, has not been satisfactory. It is built in such a way that any jar or side force will disarrange it. This is very discouraging, to say nothing of the loss of time. After trying various schemes for making it stable and finding them all more or less vexatious and unsuccessful, the writer finally devised a wall form of this apparatus, which has now been in use several years and has proven entirely satisfactory. A line drawing and a front view photo are shown herewith.