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THE OUTLOOK FOR A BETTER CORRELATION OF SECONDARY SCHOOL AND COLLEGE INSTRUCTION IN CHEMISTRY[1]

IF the question "Should more credit be allowed by institutions of college grade for work in chemistry done by pupils in secondary schools?" were asked of any considerable number of teachers in those schools it is easy to believe that the majority would make an affirmative reply, and that all would at least be inclined to add to the query the traditional language of the examination paper, "If not, why not? Give reasons for your answer." Inasmuch as the present conditions with respect to the correlation of the work in the two grades of schools is admittedly unsatisfactory, and since these conditions are essentially determined by decisions on the part of the colleges, it is fitting that the situation should be occasionally reviewed, with the purpose of finding out, on the one hand, how far the present situation can be defended and, on the other hand, of seeking means by which better results can be attained. Others have dealt with this subject from various standpoints, and the statements which follow are made less with the expectation that anything like a final word will be said, than the hope that a contribution of the experiences of the teachers in one more laboratory, and a few of the conclusions which they have reached, may do something to aid in the comprehension of one of the most perplexing

[1] Presented at the second decennial celebration of Clark University, Worcester, Mass., September 17, 1909.

problems which confront the teacher of elementary chemistry to-day.

The experiences here recorded have been gathered from the routine of instruction in a technical school, and it may be considered doubtful by some whether observations made in the laboratory of a technical school in which the instruction in chemistry becomes a part of a "step up" system of requirements (that is, one in which successful work in subjects of later years is directly dependent upon a thorough grounding in earlier subjects to a degree that does not obtain in the less rigid sequence of studies in the college) should be taken as a basis for conclusions bearing also upon college work; but, while such doubts may be justified in the case of a limited number of institutions in which chemical instruction is merely a part of a general college course, it is increasingly true that more and more students from all colleges are seeking the technical schools to complete some of the professional courses which they offer. In the case of the university the technical school may well be a part of its own system; in the case of the college it means that its reputation for efficiency in teaching is to be unexpectedly tested by some other group of instructors, and it should be as much a matter of concern to them to see that their students have an adequate preparation in the sciences as to see that they are soundly taught in mathematics or the humanities. Many of the colleges have much room for improvement in this respect.

Let us first look at the situation as it apparently exists at present in some of our typical institutions as indicated by the following brief summaries. The term "entrance requirement" is assumed to represent the work of a year with the ordinary time allotment for chemistry in the preparatory schools. The data have been obtained through direct correspondence with representatives of the institutions mentioned.

1. *Yale College.*—Does not require chemistry for entrance. Students may take an examination for advanced standing, but rarely do so.

2. *Harvard College.*—Those who have passed the entrance requirement take the same lectures as those who have had no chemistry, but they have special laboratory work and more advanced instruction in a special division. They are also allowed to take a first course in organic chemistry in the freshman year. Admission of such students to work in qualitative analysis has not proved successful. Those who present more chemistry than the entrance requirement are individually considered, but are rarely excused from college work on the basis of secondary school work.

3. *Cornell University.*—The entrance requirement is nearly the same as that of the College Entrance Examination Board, but the passing of this examination does not secure credit for introductory inorganic chemistry in the university. The student may take an examination for advanced standing if he desires.

4. *Columbia University.*—Those who pass the College Entrance Examination Board examination are admitted to a special course of lectures in chemistry, including a somewhat advanced treatment of the subject.

5. *Syracuse University.*—For one year of chemistry in a normal school credit is given for elementary chemistry in college, provided the student takes another course in chemistry and passes well. After one year of chemistry in a secondary school, pupils are allowed to take the regular examination in elementary chemistry, and if they pass, credit is given for that course. If chemistry is accepted for ad-

mission the student is admitted to second-year classes, but no credit is given for elementary chemistry.

6. *Washington and Lee University.*—Students from secondary schools with the equivalent of Remsen's "Briefer Course" are admitted to a course including physico-chemical topics and to qualitative analysis. If they do well, they are excused from the former at Christmas, and continue with analytical chemistry; otherwise they continue the course in inorganic chemistry through the year. A few students from selected schools are admitted at once to qualitative analysis, but no college credit is given.

7. *Washington and Jefferson University.*—Students from a few selected schools are given credit for the first year of chemistry in college, provided they take a later course in chemistry and attain a high pass record. Others are required to pass an examination before any credit is given. Chemistry is given in the sophomore year in this institution.

8. *Wellesley College.*—An advanced course is provided for those students who have had a year of chemistry. Smith's "College Chemistry" is used, and a somewhat exacting line of experiments is required. Some quantitative experiments, some volumetric analysis and some inorganic preparations are included.

9. *Chicago University.*—Students who have completed one year of chemistry in an accredited school are admitted to special courses and complete the work preparatory for qualitative analysis, or elementary organic chemistry, in about two thirds of the time required by beginners; that is, they complete two majors in chemistry in place of three. The work of these two majors is carefully adapted to utilize and clarify the knowledge already gained.

10. *University of Michigan.*—For a year of chemistry at an accredited school four hours of university credit are allowed (sixteen hours per semester is full credit). These students are admitted to a course somewhat less elementary than that given to beginners.

11. *University of Illinois.*—A full year of chemistry in a secondary school is accepted in place of one semester in the university, provided no more chemistry is taken (and provided chemistry is not offered for entrance). When the student continues in chemical subjects he is advised to take the regular course of lectures in chemistry, but spends less time in the laboratory.

12. *University of Wisconsin.*—Credit is given for entrance chemistry to the extent of one or two units out of fourteen. These students enter the same classes as the others, but have a slightly different laboratory course. In the course of two months they appear to be on about the same footing as those taking the subject anew.

13. *Lehigh University.*—Up to two years ago certain certificates were accepted from secondary schools but the results were so unsatisfactory that an examination has been substituted. Those who fail take elementary chemistry; those who pass are admitted to a course in theoretical chemistry.

14. *Sheffield Scientific School.*—If the student passes entrance chemistry, he is allowed to take an examination to pass off the elementary course in the scientific school, and if successful he is admitted to qualitative analysis. Very few students are thus admitted.

15. *Stevens Institute of Technology.*—Students pass an entrance examination like that of the College Entrance Examination Board, but the instructor finds that he can not make use of the earlier work,

and all students take a course in elementary chemistry.

16. *Worcester Polytechnic Institute.*—Earlier attempts to examine upon a limited portion of elementary chemistry with the purpose of definitely eliminating this from the college course were not successful. Note-books are now examined, and when these indicate a satisfactory course, the students are placed in separate divisions and given a different laboratory course. They attend the same courses of lectures as the beginners.

17. *Massachusetts Institute of Technology.*—Students who have satisfied the entrance elective requirement are admitted to a special class during the first term, and the lecture and class-room instruction, as well as the work in the laboratory, are designed to take advantage of the work already completed by the student in the preparatory school. The effort is made to introduce new lines of experimentation, as well as to reawaken interest in earlier work by encouraging the student to interpret the phenomena which he now studies in the light of his more extended experience, and with the aid of such additional concepts as have been introduced into the lectures and recitations. The two divisions of the class are united for the work of the second term.

Of these seventeen institutions one does not recognize chemistry for entrance, two make no specific provision for students who have had chemical instruction in the preparatory schools, three provide special laboratory instruction, but give no definite college credit, six provide special instruction in both lecture room and laboratory, but without giving college credit, while two give some college credit on certificate, and four excuse students from elementary college courses after special examination.

These institutions are sufficiently varied as to locality and type to justify the assertion that they represent the present practise on the part of thoughtful college teachers. That there is apparently much duplication of effort is at once evident, and that this must result in some loss of time, energy and enthusiasm hardly requires argument. Why, then, have we so long tolerated this apparent waste, and why do we not immediately take steps to avoid it? The answer seems to me to be this: It appears to be impossible to select any point in the chemical instruction received by the members of a college entering class at which they have such a sound understanding of the facts and principles already studied that this knowledge may safely be accepted as a foundation for further college instruction; or, if such a point may be selected, it lies so near to the beginning of the college course as to make a definite excuse from this small amount of work practically meaningless. There is, of course, a small proportion of students to whom this statement is not applicable, but it holds true of so large a proportion that it determines the character of the instruction which is given to all students who have had any previous chemical instruction. The situation does not appear to be appreciably better in institutions having a definite entrance requirement in chemistry than in others.

Some of the reasons for this state of affairs we will try to consider presently, but let us first look at the conditions as they confront the college teacher who has an earnest desire to enable his students to utilize every advantage which they have gained, remembering, however, that in these days it is not a question of individual but of class instruction, so far as the main features of a course are concerned. The college teacher or the teacher in a technical school will find among the members

of a single class students of each of the following types, with many variations:

Student A.—An intelligent, reasonably thoughtful pupil from a school where there are small classes, a well-arranged one-year course and a judicious, helpful teacher. Such a student is a source of constant pleasure, and much can be done for and with him.

Student B.—The chemical enthusiast who, during a course of one or two years' duration has been permitted, because of his enthusiasm, to work extra hours or to assist his teacher. He has won high praise and occasionally merits it, but too often the college teacher learns to dread the expenditure of energy and tact which is necessary to retain the good-will of such a student while bringing him to realize that a more profound knowledge than his own may be possible; yet, when the battle has been won, perhaps half of these men make excellent students.

Student C.—The student who has had two years of chemistry, in a course of ordinary excellence, under average conditions as to equipment and teaching. He feels, with some reason, that all this should count for a great deal, and no argument will wholly displace this notion. He works without interest, and generally badly, and is a heavy load to carry. You ask, Why not transfer him to the work of the higher years? We reply, Because experience has shown that he probably lacks adequate preparation for it, and will fail in it. The only practicable alternative lies in so arranging his laboratory practise that he shall have as large a measure of new work assigned him as it is possible to oversee without disproportionate attention on the part of the instructors.

Student D.—A student of moderate ability from an average school with a year of experience. His credentials are clear, but he has perhaps had little personal instruction and his knowledge is ill-arranged and vague, as to both fact and principle. He has no confidence in himself, and there is very little which is final in his preparatory work. His is one of the most difficult cases to provide for at the start, but often turns out well in the end.

Student E.—A student who has spent a year, or more rarely two years, under inadequate instruction, which has been worse than useless. An entrance examination may exclude him, but under other systems he becomes a troublesome factor in the complex problem and it may require some weeks to discover or be sure of his trouble. His place is with those students who take up the study of chemistry as beginners and his exclusion from the more advanced class is logical; but a transfer to elementary classes when these are provided is almost certain to breed discontent in the individual, and often disarranges other work of the term which, by that time, is well advanced.

But the confusion of interests does not end here! The types just referred to have been selected essentially along the lines of general efficiency of instruction and length of courses. It must further be recalled that even efficient teachers vary widely in their conceptions of the ground to be covered, and the college receives students who, during a single year of chemical instruction, have had the chief emphasis laid upon descriptive chemistry, others where it has been laid chiefly on "theoretical chemistry"; again others where the course is largely one of physics rather than chemistry; and, finally, where considerable qualitative analysis has been included even in this brief time.

The conditions appear, then, to be these, briefly stated: Experience indicates that the pupils who have had even two years of

instruction in secondary schools are, in general, not in a condition to take up work in chemistry which is more advanced than that of the first year in the college, and for students who have had but a single year there is at present so little that can be regarded as common knowledge that the present apparent duplication of work seems unavoidable. Regarding this duplication more will be said presently.

Let us next face the question, Why is it that secondary-school courses have failed, and, as it seems to me, are likely to fail, to serve as substitutes for any considerable amount of college instruction in chemistry? The reasons are far from simple, and they need some analysis. We may distinguish, I think, at once between certain factors which, since they are inherent in the nature of our science or in the period in the pupil's life in which the instruction is given, are common to all schools, and those elements in the situation which are the outcome of varying fitness on the part of the instructors.

Is it not true that chemistry itself presents some peculiar difficulties? It is often said that "physics is taught better in the secondary schools than chemistry." I am inclined to think that, as a general statement, it is essentially true. But might not the full truth be better stated in this form: "Physics is more effectively taught than chemistry in the secondary schools because physics is an easier science to teach"? It is true that chemical phenomena are plentifully at hand, and that our very life processes are dependent upon them; yet they are not recognized as such and are essentially unfamiliar. The teacher of chemical science, and the practitioner who seeks recognition for his achievements, are alike forced to realize that the tools which he employs, the working conditions which he establishes and the terms in which the results of his labors are to be expressed are unusual and strange and, because of this, more difficult of comprehension by his fellow men.

The beginner in chemistry is at a similar disadvantage as compared with the beginner in physics. In his work in physics the pupil handles, for example, the balance, the mirror, the pendulum or the battery, and he makes his measurements in units which are largely familiar to him; and the phenomena which he observes are not foreign to his daily life. On the other hand, the very test-tube and beaker to which the student of chemistry is immediately introduced are unaccustomed objects, the bottle of acid is still more so, and we often accentuate the situation by asking him to don breast-plate and armor for his personal protection, in the shape of aprons or rubber sleeves. While, on the one hand, the concepts and laws of physics may not be properly alluded to as "easy," yet it seems to me evident that they make less demands upon the intellect and the imagination than the fundamental principles of chemistry, if these principles are to mean more to the pupil than mere memorized statements.

With the growth of the holes in the pupil's clothing the strangeness of the beaker, test-tube and acid bottle lessens, to be sure, but he is coincidently introduced to increasingly complicated phenomena; he is asked to conceive of molecules, atoms, ions, even of electrons; he is asked to form some notion of valence, to construct chemical equations, and to "state all that they express"—a thing which you and I with our greater wisdom and experience may well hesitate to attempt. He must master the principles of stoichiometry, that branch of chemical science which seems to baffle the human intellect to a degree that never ceases to amaze even experienced

teachers. It may even happen that his course includes such concepts as those of chemical equilibrium, the mass law, or the phase rule which, in their relation to the proper subject matter of a secondary-school course, somehow remind one of the records of those early chemical processes found in the first chapter of Genesis in which it is quite incidentally stated that near the close of the fourth day the Lord created "the stars also." It is easier to forgive the ancient recorder for his lack of a due sense of proportion, than to excuse the twentieth-century instructor.

Keeping in mind, then, the newness of the chemical processes and chemical concepts, and the fact that the latter necessarily make considerable demands upon immature imaginations, may we not fairly ask whether it is actually reasonable to expect that a young boy or girl of fifteen to seventeen will gain a really clear insight into chemical science in one year; such an insight as will serve as a safe foundation for a chemical superstructure without further strengthening through review? I think I can hear teachers answering warmly in the affirmative. But, again, do they not have in mind the exceptional rather than the average pupil? It seems to me that experience indicates that the most that it is wise to attempt in the case of the large majority of pupils of the ages named is to broaden their horizon by teaching them to interpret common phenomena in the terms of chemistry, and with the aid of only the simplest fundamental principles to help in the understanding of those terms, leaving the meaning of the more abstract conceptions to be learned in a college course, or by later and more mature reading if the pupil is not destined for college, but has an inquiring mind. I believe that the disparity between the immaturity of mind of the pupil and the demands of the subject-matter assumed to be taught has been far too much ignored. I think this is the more true in these days when it seems evident that our educational system, through its multiplicity of subjects and the over-prominence of the baneful influence of the examination paper, tends to remove nearly all opportunity for concentrated or independent thought on the part of the pupil, or of originality in methods of instruction on the part of the teacher.

I believe, then, that even the competent teacher, with adequate equipment and the usual time allotment must find great difficulty in teaching chemistry to even the more receptive pupils at the secondary-school age so thoroughly as to permit the college to substitute it for any considerable part of the college course, at least under present conditions. For, let it be said with all humility, we college teachers too often made a sad mess of it even with the advantages as to maturity and environment, which we presumably possess.

The statement is sometimes made by college teachers that they would prefer to receive students without previous chemical experience, and the question may be raised whether or not it would be better to abandon entrance requirements in chemistry. I believe it is the opinion of the majority of college teachers, especially of those who have given the problem the most careful thought, that this would be very unfortunate. I should consider it so for at least two important reasons: first, because, while formal excuse from a definite portion of the college work is not yet generally practicable, the experience already acquired by the student can be made very helpful if judiciously utilized, and second, because it is mainly through increased cooperation between the schools and the colleges in an effort to secure better working conditions

for the teacher, and the adoption of a rational course of instruction in the secondary schools, which will take into account all of the pupils, rather than those alone who propose to enter college, that we may hope to attain better results.

It is noticeable in the statements quoted above regarding the present practise in the various institutions, that the state colleges are apparently giving a greater amount of definite credit for work in the secondary school than the others. This is frankly stated by some of the college teachers to be due to the closer organic connection of the state university with the general school system, and is admittedly done under slight pressure. On the other hand, these institutions have, through the system of school inspection on the part of the state universities, a more direct means of influencing instruction in the preparatory schools. The outlook for better conditions in the future is generally regarded as favorable.

Perhaps we may ask just here, What would these better conditions be like? It is probably fair to say that they would be such as to avoid duplication of work. Obviously repetition and duplication should be reduced to a minimum, and no one would welcome changes which tend to bring this about more than I. But I think it is possibly true that there is less actual duplication of work than is commonly supposed in those institutions in which the students who have had a year or more of chemical instruction are segregated in separate divisions. Let us take a concrete case by way of illustration. The pupil in the secondary school prepares chlorine, using salt, sulphuric acid and manganese dioxide, or hydrochloric acid and manganese dioxide. The time available rarely permits the use of any other method, and the chemical changes involved are sufficiently complex to present some little difficulty for their complete comprehension. Few pupils, as experience shows, really understand that this is a typical, and not an isolated or unique procedure, and the rôle played by the manganese dioxide is but vaguely grasped. It *is* true that such students are asked to again prepare chlorine from these materials in the college laboratory, but they are at the same time required to study the action upon hydrochloric acid of such agents as lead dioxide, barium dioxide, hydrogen dioxide, potassium permanganate or potassium dichromate, and to discuss the changes involved from the common point of view of the oxidation of the acid, and the proportion of actual duplication of work is really small. Similarly, in the study of the action of acids upon metals, while it is desirable to ask the student for the sake of completeness to repeat the familiar process for the preparation of hydrogen from zinc and sulphuric acid, this becomes a mere incident in the series of experiments and in the broader discussion of all phenomena observed, which may well go so far as to include the principles of solution tension, in the case of such students.

It is, apparently, work of this general character which many college teachers are offering to those who have had earlier chemical training. The laboratory work is, as we have seen, frequently accompanied by lecture demonstration and recitations of a corresponding grade, and while it does not, of course, appeal to the student as a step in advance, as would some other procedure which seemed to give a stamp of finality to his earlier studies, it may well be questioned whether it does not better foster his intellectual welfare than the more alluring plan could do. It should, however, be the purpose of the college teacher to keep closely in touch with the actual and probably increasing average

attainments of the pupils sent to him, in order that he may take all proper advantage of the instruction already given, and it is probably true that a larger number of institutions should offer such moderately advanced courses than is at present the case.

I propose next to refer briefly to one or two specific points at which it appears to me that the instruction in the secondary schools might be improved. I do this with much hesitation, for I realize that those very details or methods which perhaps fail to appeal to me may well be very dear to another, and I realize that I should be loath indeed to have the actual efficiency of my own instruction judged by certain alleged quotations on the part of some of my students, or even by the subsequent acts of many of them. A conspicuous instance of the failure of some of our hopes was afforded by a statement made by one of our students in a recent written test that "nitroglycerine is used as a lubricant."

A question which many find difficult to answer is this: How far, taking into account existing and not idealized conditions, is it just to regard note-books as an index of the efficiency of the instruction as given in a particular school, or college? I shall not be rash enough to undertake to answer this beyond expressing a conviction that while a note-book which is well kept and carefully corrected probably indicates careful, efficient teaching, a relatively poor note-book may represent more accurately an overburdened condition of the teacher, which prevents adequate inspection and correction, than actual inefficiency in instruction. For it is often true that much of apparent error in the records may have been actually corrected in conference or class-room. This does not, however, apply to some of the atrociously bad specimens which are occasionally met with, nor, on the other hand, does it ignore those note-books which are obviously not records of work done, but studiedly prepared exhibits, executed through connivance of teacher and pupil at the expense of a fundamental principle of all scientific work, rigid honesty.

Is it not true that too many teachers are contented to have their students perform more or less perfunctorily the magic "forty experiments" which are said by some one else to represent a suitable course, rather than to vitalize their instruction by devising ten, twenty-five, fifty-five or any other number of experiments of their own to illustrate the facts or principles which they themselves desire to fix in the pupils' minds, and to see that these are actually discerned. The busy, often overburdened teacher, will not always find time or energy to devise an entire course of instruction, but the introduction of even a limited amount of well-considered experiments or class-room instruction which represents the personal equation of the individual teacher does much to maintain enthusiasm for the teaching which is often reflected in the work of the pupils as well.

The deadening tendency of a mere following of a course of experiments laid down by others shows itself also in a disposition to regard each experiment as a thing apart, the nominal completion of which is a cause mainly for relief, is also reflected in many instances in the notes submitted, which are long and minutely descriptive of really insignificant details, but miss the real point of the experiment. This, in turn, comes from the fact that the pupil is not sufficiently informed why he is asked to perform the experiment at all, and in the strangeness of the work he naturally confuses the important and the unimportant. For example, he is often apparently left to think that a description of

"the apparatus used" is as essential when he pours silver nitrate solution from a bottle into a test-tube containing a halide solution, as when he is preparing nitric acid from saltpeter, and he elaborates his descriptions with the same fidelity in the former case as in the latter, with a very considerable aggregate loss of good energy on his part and that of his instructor. But that is not the worst of it, for he gains an idea that all experiments are to be treated with similar uniformity in other respects, even including his search for their hidden meanings. I do not, of course, advocate telling the student what is to happen and then asking him to say that it did occur, adding, possibly, the color of a precipitate; but I do believe that a great deal would be gained if nearly all experiments, or groups of experiments, were more carefully prefaced in the laboratory directions by a brief statement regarding the principles or the types of changes involved, and if, then, the student were encouraged to make his observations with reference to these statements and were required to show that he understands how the given experiment actually confirms the points in question. This would do much to avoid what is at present a wasteful expenditure of time, muscular energy and eyesight—all of which could be used to increase the pupil's experience, and it would partially, at least, eliminate the vague groping which results as those appalling scientific monstrosities which follow the words "I conclude" in the note-book of many a conscientious student. Have you ever recalled the bewilderment of your student days, when you had no idea what to look at among so many phenomena? Have you ever taken a half dozen experiments and candidly asked yourself what *you can legitimately conclude* from what has been performed? It is very much like trying to answer some of one's own well-sounding examination questions; a procedure which often causes them to lose their attractiveness.

Do we not, then, tend to lay too much stress upon mere performance of experiments, and devote too much time to the making and reading of descriptive notes which are often copies of the experiment manual, and too little time to helping the pupil, through judicious suggestions regarding the experiments and through questioning at the work-table and in the recitation room, to comprehend what it is all about, and the relation of a given experiment to others already performed?

In order that the perplexities of the college instructor may be brought more clearly to mind, and in order to illustrate certain types of note-books, I reproduce here a few pages from the books presented in connection with the entrance elective requirement of the Massachusetts Institute of Technol-

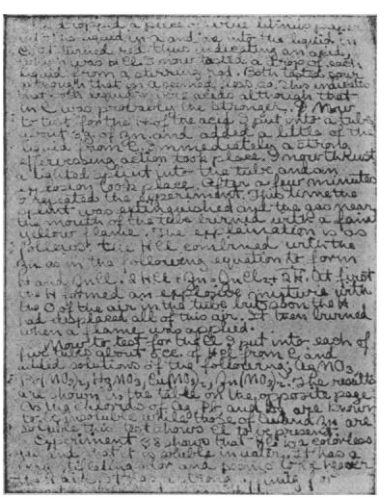

Fig. 1

ogy. The first (Fig. 1) is a representative of a rather small number of superior books. The observations are carefully recorded, the deductions are valid and well expressed and there is evidence (not shown in the cut) that the note-book had been inspected

and corrected. Under existing conditions as to numbers of pupils to be taught it is probably too much to expect that all will attain a standard which this note-book ap-

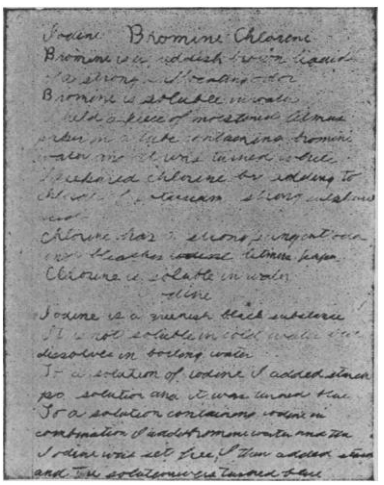

FIG. 2

pears to represent. To all appearances the records are original and the instruction efficient.

The pages reproduced in Figs. 2 and 3 are of a not uncommon type. The first

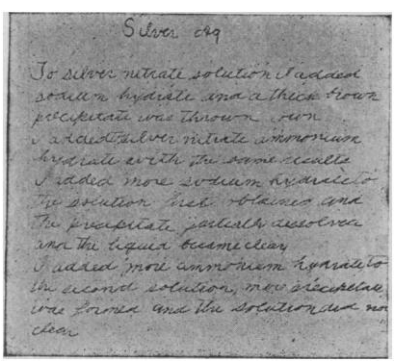

FIG. 3

leaves one in doubt as to what part of the work has been performed by the pupil, since the statements made regarding the physical properties could have been copied from a book, the records of experiments performed are distinctly wrong and, in the case of the alleged preparation of chlorine, would, if ever followed, lead more directly to a residence at a hospital than to any worthy scientific end. Fig. 3 shows a page which makes no pretense of being anything more than a mere record of a useless mixing of a few solutions, and moreover these records are also entirely wrong.

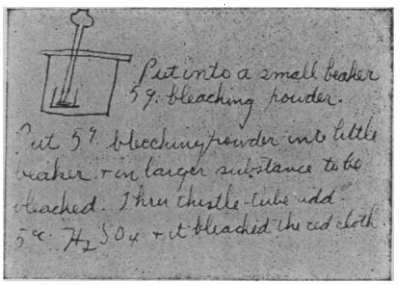

FIG. 4

The two pages just commented upon did not bear any evidence of inspection on the part of the teacher; that shown in Fig. 4 bore the stamped legend "approved," but a careful inspection leaves one in doubt as to what particular feature of the record warranted this, unless it may be the evidence of sympathy (?) on the part of the pupil with the tendency towards spelling reform.

These are not exceptional pages; they are representatives of many that pass under our inspection each year, and I ask you, with all sympathy for the teachers concerned, what evidence does any but the first give that one may safely omit a review of the ground supposed to be covered by this work in a college course which is primarily expected to furnish a safe foundation on which there is afterwards to be erected a very considerable superstructure of chemical knowledge? Are we not justified in our perplexities?

I should like also to appeal to the teachers in the preparatory schools to encourage

the pupils to better economize their laboratory time. Too many are allowed to placidly watch a crucible heat, or a solution boil, when other experiments might be in progress at the same time, and these habits are difficult to overcome. I should like to suggest, too, that some of the most promising pupils are often seriously harmed by allowing them to work too much by themselves, or by encouraging them to go beyond their depth in a particular line in which they appear to be specially interested, to the detriment of their fundamental work. Such pupils usually come to college with an exaggerated sense of their own attainments and it frequently requires long and tactful persuasion on the part of the college instructor before they can be reduced to reasonable humility.

On the other hand, I venture to plead that all proper encouragement be given to pupils to take advantage of such special privileges as the colleges offer. It is not an infrequent occurrence to find a pupil who tells us that he has been advised by his teacher to take the elementary course for beginners as one in which he will incur less risk of failure. Were the examination the goal of the course, there obviously would be little to criticize in this suggestion; its effect upon the student as an embryo scientist is seldom happy.

In conclusion let us ask, how can we make the work in chemistry in the various institutions more mutually helpful?

1. By a more extensive cooperation on the part of the colleges and technical schools in the way of separate courses for those who have taken chemistry before entrance, a closer study of the problem on the part of all, and a readiness to recognize improved conditions.

2. By an intelligent delimitation of the secondary-school course, so that it will only offer what the pupil can best assimilate at the age and in the environment in which he works. This is too large a topic for discussion in this connection, and it is sadly complicated by the necessity for furnishing a course which shall be alike useful for the pupil who expects to enjoy college opportunities and his less fortunate associate. I plead, as I have often done, for a course which is fundamentally descriptive in its character. I do not mean a mere catalogue of facts, but a course in which selected facts are taught for some specific reason, which is invariably explained to the pupil, and in which these facts are interpreted for him in terms of the simplest of the fundamental principles and concepts, so often repeated and constantly utilized that they may ultimately mean more than memorized paragraphs from what he may later remember only as "a book with a green cover." I think there can be no greater mistake than to suppose that such a course is a less worthy one than such as is often pointed to with pride as a "theoretical course," and no teacher should consider that it will demand less than his best efforts, supplemented by all his knowledge, to utilize the opportunities for helpful and thorough instruction which such a course affords. It is, of course, difficult to determine whether or by how much the instruction of the boy or girl destined for college should be differentiated from that of their fellow-students, but I venture to hope that a decision may yet be reached, through cooperation, which may permit us to select a limited field which shall be so well covered as not to necessitate repetition in college, and that this may be done without prejudice to the candidate or non-candidate for college credits. How soon this will come, or how large this field may be, I do not venture to predict.

3. By increasing the time alloted to chemistry in the secondary schools until it

is more nearly commensurate with the dignity and difficulty of the subject. Whether such increase should amount to one third, or some larger fraction of the present time allotment is a point which those actively concerned in the teaching can best determine. The increase in time should be asked for mainly in the interests of those who will not pursue the study of chemistry further, but it will also presumably hasten the time when a definite point of articulation with the college work, as just suggested, can be fixed.

Finally, there is the urgent need of decreasing the demands made upon the teacher of chemistry in the secondary school for duties other than those of chemical instruction, and also a critical need for relatively more instructors. I believe that a very large proportion of the unsatisfactory results now noticeable are due to the fact that in most of our schools it is not humanly possible for the teaching force to accomplish what should be expected of them, or to be at the desk of the pupil when he reasonably needs assistance. In some schools which have come under my observation the distribution of supplies must be attended to by the senior (or often the only) instructor, an operation which consumes a half hour or more.

Probably no science demands for its understanding by the beginner more individual instruction in laboratory and classroom than chemistry, and the school authorities should realize this. When they do we shall have much cause for rejoicing, and much of the present groping and bewilderment on the part of the young student will give place to enjoyment in the study of a science which is really second to none in its attractiveness or value when pursued under favorable conditions.

It is a pleasure, in closing, to say that I feel that too much praise can hardly be given to the loyal, hard-working, intelligent and inspiring teachers who are accomplishing so much in behalf of our science in the training of the beginners. No thoughtful college teacher can fail to recognize the good work done in very many schools throughout the country, and while many feel that more definite recognition in the college curriculum can not wisely be given to this work at the present time, I am sure from the messages which have recently come to me from many colleagues in many institutions that there is an increasing appreciation of the fact that the way to better things lies through a sympathetic appreciation and study of our common problem and our common difficulties.[2]

If there be a determination, on the one hand, to undertake only so much as can be well taught and to give the largest practicable vitality to the instruction, and, on the other hand, a disposition to promptly recognize and utilize every bit of ground gained which offers a secure foundation for later work, a more satisfactory situa-

[2] In a discussion which followed the presentation of this and other papers on educational topics, a statement was made by a secondary school teacher of recognized standing to the effect that many such teachers had become indifferent to the opinions of college instructors, since it is "impossible to satisfy them any way." While I heartily sympathize with the thoughtful teacher who desires to teach his subject in his own way and with his own ideals in view, and deplore any attitude of the colleges, collectively or individually, which tends to interfere with this, it seems to me that the common cause of greater total efficiency in instruction can hardly be served by ignoring the opinions of the colleges, even if they are mistaken. May it not be true that the secondary school teachers lack some courage, or at least some persistence, in forcing their convictions upon the college teacher? They have the privilege of speaking from a fullness of experience with the young pupil which the college instructor usually lacks.

tion than that which exists at present can hardly fail to result, even though the degree of recognition of secondary school instruction may fall short of that which some desire.

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HIGH SCHOOL CHEMISTRY: THE CONTENT OF THE COURSE[1]

Every teacher in the high school of to-day finds himself in stimulating circumstances. He is obliged to question himself closely as to the part that his subject plays in the curriculum, for, at least in the large cities, the long-discussed change in the character of the high school is upon us. The reason for the change is found in a realization of the facts that in the past, high school education has been enormously wasteful; that eighty to ninety per cent. of our pupils do not complete the course; that only a small part of the remaining per cent. achieve the purpose for which the whole course has been framed, that of entering college. The evidence that the change has actually begun is found in the establishment of trade and vocational schools, in the frequent discussion of questions pertinent to these points, and in the statements of principals and superintendents that something must be done to stop the enormous educational waste; and in their declaration that the high school must meet real needs, must give the boy or girl the education that is best for him or her, as a member of the human group, with little reference to college entrance.

Among the changes that are coming from a recognition of these facts, we find the importance of science in the high school largely increased. The fact that it is science that has produced the great material advance of the past century makes it certain that in the further turning from formal to practical education, science will play a larger part. It is the purpose of this paper to inquire into the manner in which these changing conditions are reacting on the high school course in chemistry, and to discuss some of the considerations that are determining, or should determine, a new course of study. The speaker wishes also to discuss, in general, the problem of high school chemistry, presenting personal and perhaps even extreme points of view.

We may classify the various forces that are shaping the new course as external and internal. In the first class we find: (*a*) a lessening of the college influence, due to a realization of the necessity of educating for other purposes than college entrance; (*b*) a tendency to put chemistry earlier in the course and to give a second year of it; (*c*) what we may call the lay demand for practical education.

The lessened college influence will give to the body of secondary teachers not only greater freedom in the selection and arrangement of their material, but what is of even more importance, because it serves as a stimulus to their creative ability, a realization of the importance of their own great work and their responsibility for it. The lack of this kind of freedom is in part responsible for the condition that exists to-day when the high school, paying comparatively high salaries, can not get enough good men, while the college apparently has more than it needs at a smaller compensation. This is not the least of the evils that have resulted from the college domination of the high school. Others have often been pointed out and are well known. The course of study can never be adapted to the real needs of the high school so long as it is framed by the

[1] Presented at the second decennial celebration of Clark University, Worcester, Mass., September 16, 1909.