When should our students begin to specialize is a question that will probably never be settled to the entire satisfaction of all teachers in colleges of pharmacy. The following discussion by Dr. George D. Beal is enlightening because it presents a similar problem from the standpoint of the employer of college graduates. His arguments and illustrations are convincing and his paper deserves careful study.—C. B. JORDAN, *Editor*.

## CHEMICAL EDUCATION AND INDUSTRIAL RESEARCH.

BY GEORGE D. BEAL.[1]

In accepting the invitation to prepare a paper for the Chemistry Teachers' Conference, I did not realize at the time that my words were to be a formal opening to a symposium on Chemical Education and Industrial Research. However, at the Baltimore meeting of this section I had the privilege of speaking on the teaching of analytical chemistry, when I presented some ideas similar to those which I intend to advance to-day. My laboratory schedule did not meet with the approval of some who discussed that paper, so that I am glad to have this opportunity of restating my position, this time in connection with what some may regard as a higher plane of endeavor.

Thinking back over two years, I recall that our divergence of opinion came over the question of the content of a laboratory course in analytical chemistry. It has been my experience in teaching this subject that the ideal course, as in organic or physical chemistry, is one that is based upon typical operations and reactions, rather than one which empirically goes through a series of experiments chosen merely because they represent determinations that may be made by the student if he later chances to enter a control laboratory.

If every student upon entering college was so omniscient that he could accurately and adequately foretell his professional future, his curriculum might be arranged to fit his future needs. Think of the medley of courses we would then find described in our catalogs, and of the predicament of the instructor who was required to correlate the grades because of the requirements imposed by regulatory and licensing boards. Since we have not the gift of prophecy, and must for administrative purposes have some uniformity of requirement and performance, any curriculum and any course therein must be based upon that parable of the house that was builded upon a rock, which because of the strength of its foundation could not fall.

One of my early duties in the teaching profession was to give instruction in quantitative analysis to a large class of agricultural students. Many of them objected strenuously to spending their time on the determination of simple radicals such as chloride and sulphate in salt mixtures and the titration of samples of organic acids and soda ash. It would be so much better, they reasoned, to substitute samples of soil and fertilizer for these simple things and thus quickly obtain precious practical experience. It was only when they came close to the end of the semester and took up the more complete analysis of limestone and rock phosphates that they realized the effect of a lack of experience and technic.

As a result of their constant complaint I finally took my problem to the professor in charge of the work in soil fertility, for which my course was prerequisite.

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This gentleman, an authority whose fame was world-wide, was good enough to sympathize with me in my dilemma, but asked me to continue just as I was doing. His words were in substance:

"These students must come to us with the ability to weigh, to filter and to titrate. They must understand the theories of chemical calculations and therefore must know the reactions that govern analytical procedures. We can give them outlines for the analysis of soils and fertilizers, but we cannot in the time allotted us teach them those fundamental things that will enable them to plan, execute and interpret the analyses of agricultural materials."

Just as there are both empirical and systematic methods of conducting chemical analyses, so are there empirical and systematic methods of research. The chemical monographs of the Pharmacopœia are empirical, because experience has shown the character of the adulterations that may be expected and has also dictated the simplest means of dealing with them. But the analysis of a proprietary by a purely empirical series of procedures is liable to require an indefinite time unless the operator is guided by some knowledge of probable composition, which means experience or fundamental training.

With these two general methods for the conduct of research, there is a vast series of blends with almost infinitesimal shadings. At one end of the series is that method of attack known as the "try every bottle on the shelf." At the other end is patient, systematic investigation, in which every ramification is followed to its logical conclusion. Probably the research genius is the person who, following a systematic program, best recognizes the time to apply empiricism, or, as expressed by many, to "play his hunch."

There is no doubt but that both brilliant and valuable discoveries have been made in an empirical fashion. Would you, however, as hard headed business men, be willing to entrust the development of what might eventually become one of your most valued possessions to the hands of a man whose sole recommendation was a reputation as a lucky guesser?

It would be bigotry on my part to maintain that ability to carry on any one type of research does not depend upon specific training. The man who is to effect the most profound synthesis of a new medicinal agent must admittedly be best versed in organic chemistry, and some one well trained in biochemistry will probably have most to do with the isolation of a hormone. Therefore you will say that we must include specialization in organic and physiological chemistry in the training of research chemists. But some of the very important studies now required in pharmacy are of a physicochemical nature, and the Pharmacopœia still includes a lengthy list of inorganic chemicals, while organo-metallic compounds, that meeting-ground of the two great sub-divisions, are growing rapidly in importance.

In the writer's opinion industrial pharmacy, just like industrial chemistry, will be a constantly changing profession, with new interests and new problems coming to light at frequent intervals. If therefore we have a wealth of men of a high degree of specialization in one field, and the fashion of manufacturing pharmacy changes, those specialists who cannot change with the fashion will be doomed to great disappointment.

If a man must be an organic chemist this year and an inorganic chemist next, his chances of success will be strongest if he is first of all a chemist, and afterward a

specialist. Very few students complete a curriculum without showing a relatively superior sort of proficiency, or interest, in one division over another. This, carried on into graduate study, or practical research, eventually produces the specialist. But even the specialist is of little real value if his specialty is developed at the expense of his collateral training.

We are asked frequently in our organization which division of chemical science is most profitable for specialization. We have to reply that strong fundamental training and adaptability are probably the two most important requirements. The reason for this is that we cannot accurately predict a year ahead, even in good times, what the need for research workers will be. Our needs may be, and doubtless are, different from those of a manufacturing house, but the latter is confronted with changing economic conditions just as we have been, and quick shifts of front are undoubtedly required to meet new needs or competitions.

During the past week we have learned of the experience of an eighty-year-old industrial house which has normally maintained a large and efficient research staff and which even to-day is operating to a practically normal extent. Last fall they were obliged in a general move of economy, due partly to a fear for the future, to reduce their staff 25 per cent. Notwithstanding this apparently serious reduction, they tell us that the volume of work produced has not appreciably minimized. According to the statement of one of their executives, more work is actually being done by the reduced staff than by the full staff previously. The mediocrists of the staff have been eliminated, with their hindrances to the more brilliant members, and the men remaining are working more efficiently and intensively.

In determining the personnel of the residual research force, the important criterion has been researchfulness. Proof of this is the demonstration of power by contribution or by publication. By this I make no reference to the publication by a student of a thesis or dissertation, for the reason that in nearly every such instance the idea and the spirit of the work, and oftentimes a large part of the actual content of the contribution, is the work of another and older person. Only such as can be a witness of independent thought can be considered an index of researchfulness, and no man's work as a researcher has been demonstrated until he has complied with these criteria.

Let us conclude then that intense specialization should be a sign of interest rather than of limitation, and that it will be built upon a sound foundation of general knowledge. After all, specialization on the part of the well-grounded person is no limitation to his usefulness or progress. I have mentioned on other occasions my first actual teaching connection in a university department of chemistry. There, in a well-rounded department, with eighteen members of the staff of doctorate standing, nine of them had obtained their highest degree in organic chemistry, although they were teaching and directing research as well in inorganic, analytical, industrial and sanitary chemistry. Two other examples that have been mentioned on other occasions are those of two of the three student founders of the now national honorary chemical society. One of these men, majoring in fuel chemistry, became one of the country's leading biochemists, while the other, equally determined to specialize in animal nutrition, became a fuel expert of national renown.

Furthermore, success in the field of research depends upon far more than the actual training received. Industrial research requires, on the part of some in the

higher places, at least, a sense of economic values; it requires a knowledge of what has been and is being done on the other side of the fence; it requires an ability to work and to think; it requires also an imaginative spirit and an argumentive spirit, and many times one which will take nothing for granted. Just as there are some chemists who fit into an analytical laboratory not because they are useless elsewhere but because they have a mysterious quantitative sense that the average chemist lacks, so there are also chemists who have all of those qualities that go to make the ideal research man, yet apparently lack the brilliance of some of their laboratory colleagues. Some of the soundest thinkers continue to plod, because they never get beyond the immediate problem to see the subject in its broadest relations. Others have what on first sight appears to be a lucky touch, but later turns out to be native ability, plus sound basic training, plus the inspiring examples of teachers who had a respect for things around them.

There have been many defects in pharmaceutical education in the past. Some of these are due to bias and bigotry on the part of teachers who have been regarded as leaders in the profession. It seems that in schools connected with the art of healing, including medicine, dentistry and pharmacy, there has been a greater tendency toward inbreeding in the faculties than is observed in other scientific and technical faculties. There are few faculties in pharmacy that have brought in new members from outside their own walls, who can introduce new methods of teaching and help break down conservatism and tradition.

Chemical education in the two-year course in pharmacy could not produce trained chemists. Such training in the short courses should be limited to what is actually necessary for the handling of chemical substances used in the compounding of prescriptions. The purpose of the four-year course, however, is to provide the pharmacist with a more substantial education, in which the ground work for practicing the art of pharmacy is to be reinforced with instruction in collateral branches, and at the same time backed by a more substantial preparation for the world of business and for one's proper place in community life.

The organization of a substantial four-year course in pharmacy will not be accomplished by a mere extension of the hours in each course or a multiplication of experiments in laboratory courses. New subject matter must be added to curriculums and courses, and this must be carefully considered in the light of more adequate preparation for subsequent courses. Above all, the introduction of topics and courses must be for more substantial reasons than the dictates of educational fashions and fads.

It is out of place in this paper to discuss the value of individual topics and courses in an educational program. There are two matters that may be stressed, however. One of these is the proper place of the study of economics in relation to chemistry and pharmacy. The literature in this field is ample, and the importance of the subject to any student planning to make industrial research his life work is unquestioned.

The other is the place of the library in education and research. The study of the use of chemical literature has been a development of the last twenty years in schools of chemistry, due largely to the pioneering work of the late Miss Sparks at Illinois and Mellon at Purdue. The AMERICAN PHARMACEUTICAL ASSOCIATION is one scientific society that has insisted from the beginning on the preservation of

research records through the "Report on the Progress of Pharmacy." Instruction in bibliochresis should be made a part of every curriculum in pharmacy. The college library should not be considered as a show place, but as a work room for every student in which he is taught how to use the valuable reports of workers in this and collateral fields.

Some schools with rich equipment and teachers individually of national note will continue to turn out students of mediocre grade, while others, sometimes apparently less favored will furnish leaders to the profession the country over. Such school spirits are not created over night by a board of trustees, but come from the inspiration of one man or a group of kindred spirits who keep their students welded into such a body that men separated in school by ten or more years feel instantly called to each other. The work and spirit of the school as a whole determine whether its educational pattern is one that leads to research success in pure science or in industry.

August 13, 1932.

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# COMMITTEE REPORTS

## A PROPOSED STANDARD TABLE OF POISONS.*

Because of the impossibility of framing a definition for poison which will serve as an accurate guide in every case, and also because of the unsatisfactory condition of many state poison laws, The National Drug Trade Conference has undertaken the preparation of a reference list of drugs and chemicals which should properly bear the poison label when dispensed otherwise than upon the prescriptions of physicians.

The tentative list presented in the following pages is admittedly imperfect, and is submitted with the express purpose of eliciting comment and criticism.

Suggestions are desired as to the addition of agents not included in the list, the exclusion of some which are now included, criticism of the various degrees of concentration proposed, or comments regarding any other phase of the subject.

After revision, with the aid of the comments which are expected to be received, copies of the revised list will be presented to all of those who have responded to this request.

Comments may be sent to the secretary of The National Drug Trade Conference,

E. F. KELLY,
10 West Chase Street, Baltimore.

### NEED FOR A STANDARD LIST OF SUBSTANCES TO BEAR POISON LABEL.

The need for a generally accepted, or "standard" list of substances which should bear a poison label when dispensed is found in the fact that it is practically impossible to propose a definition of poison that will serve as a sufficient guide under all circumstances. The following attempted definitions from various authorities will make this evident.

*Standard Dictionary.*—"Any substance that when taken into the system acts in a noxious manner by means not mechanical, tending to cause death or serious injury to health."

*Webster's New International Dictionary.*—"Any agent which, introduced into the animal organism, may produce a morbid, noxious or deadly effect."

*Bouvier's Law Dictionary.*—"A substance of definite chemical composition, which when taken into the living organism is capable of causing impairment or cessation of function."

*The Encyclopedia of Law.*—"Any substance which when taken, applied to the body ex-

* Report of the Committee on Potent and Toxic Drugs of The National Drug Trade Conference.