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SUGGESTIONS ON THE TEACHING OF PHARMACEUTICAL ARITHMETIC.

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Because of the existence of an amazing amount of ignorance of pharmaceutical arithmetic on the part of those entering the profession it seems to me a subject worthy of consideration. If some of the causes for this ignorance can be better understood there is perhaps a greater possibility of improving the condition.

I say amazing amount of ignorance because of the statement made by members of the Board of Pharmacy in my own state that candidates for registration are often unable to solve the simplest problems and that the number who fail in this particular is sufficiently large to bring the deficiency plainly to their attention. Also I have read at various times that similar conditions exist in some other states and I have often noticed that some students who are quite proficient in other studies, particularly those branches which might be classed as memory studies, materia medica, pharmacy, pharmacognosy, are hopelessly lost before the task of solving some comparatively simple problem in arithmetic. Whether it is just a coincidence or not, I have noticed that almost all who do well in chemistry also do well in arithmetic. I have thought that perhaps the best explanation of this is that both require the use of the student's reasoning power. However, that is not the subject under discussion.

In the beginning I wish to say that if the personal pronoun occurs frequently in this paper it is simply because what I have to say is based upon conclusions drawn from my own experience, first, from the way the subject was presented to me as a student and later, from my observation of results of my own teaching of the same subject.

Theoretically, I believe the teacher of Pharmaceutical Arithmetic has a right to assume that in the beginning the members of his class have a thorough knowledge, a practical working knowledge, of the fundamental principles of arithmetic, but, actually one is confronted with an entirely different condition. It is the province of the teacher of the subject to apply arithmetic to pharmacy. I can think of no arithmetical process with which the beginning student of pharmacy should not be familiar. Most of our students come to us with diplomas from high schools of recognized standing. Some, it is true, have had only two years in high school, but that should make no difference in this case except that perhaps more advanced training makes the earlier subjects easier. As a matter of fact I have noticed that almost as often as not the poor student in this particular is the one with the diploma. During the past year the very poorest student in my class had been graduated from what, one had a right to suppose, was one of the best high schools in our state. If I am correctly informed few pupils have any arithmetic after completing the grammar grades, since in some high schools it is offered as an elective. However, that is neither here nor there. My contention is just this: that it ought not to be necessary for the teacher of Pharmaceutical Arithmetic to teach fundamental principles of arithmetic itself.

One of the most serious conditions the teacher has to face lies right here. The total time allotted is only sufficient to cover the subject in hand and in justice to the majority of the class, the teacher cannot spend much of it in teaching fundamental principles to the minority, which minority in my experience is always present. It is possible to make some of these explanations in passing but not enough and the only alternative, it seems to me, is to give to these particular students one's personal attention out of class hours. Even this I have found to be inadequate—it helps but it cannot take the place of weeks of training or undo the bad habits of study in earlier years.

Just here, it might be best to try to account in some measure for this condition. I do not mean to arraign the public school system though the fault in part may be there, neither do I blame the teachers as individuals though I believe that sometimes they are responsible. It is probably due to a combination of conditions. We all know that from the entrance into the kindergarten to the exit from college in whatever line of study they may undertake, there are some who have a faculty of getting along and of making passing grades, and yet their knowledge is always superficial, never thorough. Such students just skim the surface of things, they never delve deep, they never know the reasons why and surface studying possibly has a much worse effect on a mathematical subject than some others. Then, and I believe this to be largely responsible for the inability to apply knowledge later, arithmetic is a thing which of necessity requires the learning of many rules. Even if they are reduced to a minimum and the reason for every one is explained in detail with due emphasis on the dangers of depending on memory, some pupils, without doubt, do little more than memorize the rule. It is only too obvious that solving problems is not a matter of memory alone. Then there is the excuse usually offered by the student himself that his mind is not mathematically inclined (in his own language, "Arithmetic always was hard for me"). In general this deserves little weight. Occasionally it may be really true but more often than not it is simply that the reasoning faculty has never been developed.

So much for general difficulties. Some need to be considered more specifically. One of the first things which becomes evident is insufficient knowledge of fractions, particularly an inability to handle decimals with ease and accuracy, and to convert common fractions to decimals and vice versa with any degree of accuracy or rapidity. This I believe to be important since it is customary to express small doses in common fractions if in Apothecaries' weight or measure, in decimal fractions if in Metric quantities. Then a thorough knowledge of decimals is a necessity in accurately using the Metric system, which every student is obliged to do. Later, this lack of information involves the student in all sorts of difficulties when dealing with percentage and specific gravity. In fact, he needs it everywhere—he cannot get on at all without it, these points mentioned are only relatively more important than others. The next place that faulty preliminary training is especially evident is in percentage and its applications where sometimes students do not seem to know the first principles. Another deficiency of large importance is proportion and what it involves. Students tell me that they do not know how to state a proportion, that they never understood the placing of the different terms. I am at loss to say why they have not understood this—I only know it is so and as with the other difficulties mentioned it is a condition we have to face. There is no other reason for tracing them back so far except that; unless one recognizes the conditions and takes them into account in teaching Pharmaceutical Arithmetic, it is impossible to hope for any great success. I am well aware also that, in college at least, the proportion of students who come well prepared is large but not so large that the unprepared may be ignored. So much for the preliminary equipment of the class with which one has to work.

Considering the various subdivisions of Pharmaceutical Arithmetic somewhat in the order they are usually taught, the various systems of weights and measures are of primary importance. Most students are more or less familiar with all of these except the Metric and that, being simplicity itself, offers no special difficulties in teaching except to those people before alluded to who have trouble with decimals. One thing that might be worth mentioning is that the use of models of the units of length, measure and weight prove helpful to the student in forming mental pictures of these various measures and making the whole subject less abstract. Until the student thinks in Metric quantities there is little meaning in the system, for him. It is, of course, expected that each individual shall be thoroughly familiar with all of these systems and where and when each is used before passing on to the consideration of their relation to each other which is a very much greater undertaking.

Much as I have said about the evils of memorizing rules, here, I insist on the students memorizing certain equivalent weights and measures and not simply the fewest possible number that one must know to get along at all. I do this for the reason that there are certain of these that will probably be needed several times every day and I consider it important that they have these at their tongues' ends because of the immense saving of time. Life is too brief and time too valuable to waste it in looking up every equivalent or in making round-about calculations. For example I think it absolutely necessary that students learn that there are 29.57 gm. in a fl. oz., 28.35 gm. in an Av. oz., 31.1 gm. in a Troy oz.; that 1 gm.=15.432 gr., 1 gr.=64.9 mg., 1 lb.=453.592 gm., 1 M.=39.37 in., 1 in.=25.4 mm.; that there are 16.23 m. in 1 cc., 473.179 cc. in a pint; that 1 m. of water weighs .95 gr. Though enforcing this as rigidly as possible, at the same time I emphasize the fact that many of these can be calculated in case they are forgotten. In other words, I show them how they have been arrived at and which are the ones that are primarily necessary. Most of these are obvious to the deep thinking student, but because of the others one can take nothing for granted. To illustrate, I show them that if they remember that there are 15.432 gr. in a gm., the weight of each ounce in gm. can be calculated by dividing 480 gr., 45.46 gr., and 437.5 gr., respectively, by 15.432. Similarly I show them that

7000 gr. divided by 15.432 gives 453.592, the number of gm. in a lb., as does multiplying 28.35 by 16. Other instances like these might be cited but probably these suffice. Likewise, I show them that, remembering that 1 M. equals 39.37 in., the reciprocal of these figures gives the fraction .0254 M. or 25.4 mm., the equivalent of 1 in.; also that the reciprocal of 15.432 gives .0649 gm. or 64.9 mg., the equivalent of 1 gr. Students will question the need for all these but with a little experience will see the convenience and saving of time. Take, for instance, the conversion of doses from one system to another; so far as it is consistent with accuracy such calculations should be mental ones and the student finds he needs both 15.432 and 64.9. Usually in instances like this the approximate equivalent would be used but it is just as easy to learn the exact one in the beginning. To go a little farther, I show them than .95 gr., the weight of 1 m. of water, is obtained by dividing 454.6, the number of gr. in a fl. oz. by 480, the number of m. in a fl. oz. Similarly the relation existing between U. S. fluid measures and Imperial fluid measures. There are a good many more that I emphasize the convenience of knowing but do not ask them to memorize, like 2.11 pints in a liter, 3785.43 cc. in a gallon, 1 Imperial gallon of water weighs 10 lb. Av.

The next important subject is specific gravity and here for the first time one is obliged to deal with rules and it is necessary to guard against those rules becoming meaningless forms. For example, to obtain the specific gravity of a solid, divide its weight in air by its loss of weight in water. While to some the reasons are quite plain—to others it is quite necessary to explain that since any solid immersed in water displaces its own bulk which is equivalent to its loss of weight so one is simply dividing the weight of the substance by the weight of an equal volume of water. Another thing which applies everywhere but particularly when dealing with specific gravity is that often a problem may be solved in several ways. In reality the underlying methods are identical but details vary. In this way they learn to reason each question individually and not depend on one hard and fast rule. To illustrate take this problem: A druggist buys glycerin, sp. gr. 1.25, at 20c per lb. and sells a pint for 80c. Does he gain or loose and how much? It will be seen at once that one must ascertain the weight in lb. of the pint of glycerin, since it was bought by the lb. This may be done by multiplying the weight of a pint of water expressed in gr. 1.25 and dividing by gr. in a lb. Thus—

$$(454.6\times16)\times1.25,$$

$$\text{Or } \frac{7273.6\times1.25}{7000}=\text{lb.}$$

The same process can be employed but using Metric quantities. Thus—

$$\text{Or } \frac{\overset{4\ 73.179}{(29.57\times16)}\times1.25}{453.6}=\text{lb.}$$

Or one may find the equivalent number of grains in a volume of water equal to a lb. of glycerin and divide that into the total measure. Thus—

$$\frac{7273.6}{(7000\div1.25)}=\text{lb.}$$

Likewise one may find the measure in cc. of 1 lb. of glycerin and divide that into the pint expressed in cc. Thus—

$$\frac{473.179}{(453.6 \div 1.25)} = \text{lb.}$$

It will be seen that the final result in each case is the same and though I do not believe the methods are equally good they are correct and sometimes a student will clearly see one and not another. Some may contend that so many methods lead to confusion in the student's mind. I can only say that I have not found it so, quite the reverse in fact. I believe there is nothing like seeing all around a subject to thoroughly understand it.

In proportion I make use of no unusual methods. If the student has understood it in his earlier studies he has no difficulty here except such as involve weights and measures and specific gravity and if these are well grounded he has none. I find one little thing helpful which I believe I can best illustrate by a problem. Cod liver oil has a sp. gr. of .92 and costs 60c a lb. What is it worth per gallon? I would have the student indicate the whole problem at once. Thus—

$$7000 : (7273.6 \times 8) \times .92 :: 60 : X \quad \text{or}$$
$$453.6 : (473.179 \times 8) \times .92 :: 60 : X$$

My idea is that no matter how many factors enter into any term of a proportion it is safer to indicate them all in the original proportion. Often they are more complex than this one given and the more complex the more danger of confusion.

Concentration and dilution are only applications of proportion and give no trouble to those properly prepared in its fundamental principles.

With percentage there is always trouble but most of this also is due to the lack of proper preparation. One thing might be worthy a little attention. Most of the texts advise the stating of a proportion and though this seems to help some students, to others it is more confusing than anything else. Again I can best illustrate by a problem. A certain drug contains 15% of extractive matter. How many gm. of extract can be obtained from 90 gm. of drug? By proportion we would have $100 : 15 :: 90 : x$.

The other method I use is simply that 15% means .15, since percent means by the hundred, and to obtain .15 of the total it is only necessary to multiply by .15.

Perhaps this is as good a place as any to say that no matter how much I may approve of the methods set forth in the text I may be using, I make it plain to students that they may use any correct method. Notice I say *correct* method. One should not tolerate for a moment the use of bad methods. I allow these variations from rule because sometimes a student has used some method until he uses it with ease and I see no logical reason why one should insist on taking the time to become familiar and speedy with another.

Alligation, I have found, has been very little taught in preparatory schools and one has to start practically from the beginning. After one has made plain the basic principles there are no difficulties except those that may be accounted for by unfamiliarity with proportions.

There is much in the manner of conducting a recitation to get the most out of it. I expect students to work all problems in the lesson assigned before coming to class but I never ask that problems be worked and handed in for correction. I believe that puts a premium on dishonesty. Instead I send a convenient number to the blackboard to work the problems I assign them and so far as possible I allow no notes made previously to be used. Then I expect an explanation of each problem, always insisting on the student's knowing the reasons for each step in the process. They soon feel the necessity of being able to work and explain the problem assigned since they know that a record of their recitations is always kept and that they in part make up the final grade. When one section has finished I send another to the board as before. In the meantime, I have those not at the blackboard working problems outside of those found in their text but on the same subject. These, I select from all the other books that I find available. I read the problems to them, trying so far as I can to vary the wording of these in order to make them think. I have used this plan for several years and find it valuable for several reasons. First, I believe there is nothing like a lot of drill to fix principles and methods firmly in their minds. Second, it promotes rapidity. There is nothing like doing a thing to enable one to do it easily. The path gets deeper every time it is used. Third, it helps me to know the capabilities of each individual better and the better I understand the individual needs, the more help I can be. If one is rapid but inaccurate I encourage accuracy even at the expense of speed. If another is slow he needs to learn to work more rapidly, though that is more a matter of temperament than training and is not to any extent within a teacher's control. When any given subject has been completed it is reviewed thoroughly, expecting students to be prepared on any part of it and here again as much as possible I give problems not in the text. Following the review, I usually give a written test these entering into the final grade, together with the daily recitations and final examinations.

Given reasonably good material with which to build and keeping one's class busy and interested with practical problems, real live questions, such as arise in their laboratory work or in business practice, they must be on the alert—there is no time for dreaming day dreams and it is only the very dull or poorly prepared individual who does not acquire at least a fair knowledge of the subject.

DISCUSSION.

Prof. Philip Asher, of New Orleans, said that the points brought out by Miss Cooper were simply reviewing the class-work over again, and he was reminded that the same faults that the students of Iowa possessed were possessed by those in the South, and doubtless by students all over the country. She had hit the key-note of the situation in using the expression, "There is a lack of reasoning power"; but he was not inclined to be so charitable as the writer. His idea was that it was not the fault of the teacher, but merely the natural tendency of students to skim lightly over the surface and not delve deeply into things. He did not hesitate to say that the modern system of preliminary education was wholly at fault. The large number of "ologies" that the modern system of school work wished to impose upon the young man was crowding out the more essential features that were needed in every-day life, whether one's vocation be that of shoemaker, carpenter, or pharmacist. The fact that arithmetic was the most essential of all studies was lost sight of. If arithmetic was properly taught in the primary schools, it would fit the student with reasoning power in after life, no matter what vocation he followed. Miss Cooper had stated that those students who took kindly to chemistry also took kindly to arithmetic, and this merely emphasized the fact that such students had been properly drilled in the preliminary schools. He had been surprised on many occasions to have to stop sometimes in the latter half of his session, and attempt to show a student with a high school certificate the principle of simple decimals; and when it came to stating percentages decimally, as one-tenth or one percent, it was astounding to see the number of failures made by students who apparently had never heard of them before. Scientific work required a knowledge of these things, and they were being constantly used, and it was discouraging to have a student with a high school education look at his teacher as though he were stating an unheard of proposition. In conclusion, Prof. Asher, commenting upon Miss Cooper's statement that the metric system had given her no trouble, said that while he did not personally teach the metric system, he knew the complaint had always been made by the teachers of his school and others that it had been the greatest difficulty they had to contend with, though as a teacher he could not see why there should be any trouble in teaching anything as simple as the metric system.

PHARMACIST VERSUS PLUMBER.

At most the average ordinary prescription business does not exceed twenty a day. I believe the majority do less. These, when compounded, would require approximately fifteen minutes each or five hours' actual compounding time; average them at 60c each and we have the sum of $12.00 gross receipts on what you would say is a fairly good prescription business. The average cost of material on these would be about six dollars. You may say it would be less, but when you take into consideration the nature of most of the prescriptions as written today you will find these figures about correct; in fact, 41 percent of 3,000 prescriptions filled in six stores in Baltimore were for unofficial products (not counting patented chemicals).

This leaves you a balance of $6.00 gross profits for which you, Brother Pharmacist, give in return the most prominent and valuable space in your store, your highest paid help besides, and the most expensive equipment is usually installed. The general expenses as a rule are greatest in this department. What have you left when you deduct these items of expense from your gross profits?

If you had a plumber to do the work instead of a registered pharmacist he would charge $5.00 for his time, leaving you a dollar for your profit. Do you wonder why a brother druggist from Canada, who has two paying drug stores, in a recent conversation, said to me: "I do not cater to the prescription business; it does not pay at the prices we get and the time required to compound them. I can do more business and make more profit by keeping my clerks busy selling merchandise and my own make goods."—*Richard T. Messing.*