Latin classes; and that I am advocating this approach in contrast with the formal and highly rationalized approach to which most of us were subjected and which is, I fear, too commonly practiced today.

And I am advocating a functional approach and, as far as is possible in a school situation, functional methods in drill and in testing throughout the course, because, as I have tried to show, I feel sure that these methods are more useful in gaining and holding the pupil's interest, in creating in him desirable attitudes toward his Latin, in giving him those abilities, knowledges and skills, which are necessary if he is ever to learn to *read* Latin, and in concurrently increasing in him those knowledges, abilities and skills which will function in his various other school activities and will continue to function in those activities in which he will be engaged throughout his life after his study of Latin in school or college has ceased.

W. L. Carr.

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## MATHEMATICS BASIC IN THE SCIENCES

SOME years ago I read a sentence or two from a teacher proud of his profession in which, borrowing the vocabulary of economics, he used some such expression as this, "The educational distributor is a factor in production." It was a vigorous way of saying that the teacher, by passing on the results of research and by stimulating the scholarly instincts of his pupils, becomes himself a factor in productive scholarship.

Speaking as a teacher of mathematics to teachers of mathematics, who like myself may not aspire to classification as scientists, I wish to claim for our profession a position of basic importance for the ongoing of science. If mathematics is basic in the sciences, the teaching of mathematics is a basic function in a scientific age. It may be our privilege to teach mathematics to young scientists whose genius far outstrips our own talents. If we do, we shall have a right to glory in their achievements, even perhaps to claim a modest part in them.

Mathematics *is* basic in the sciences. What mathematics? Basic mathematics. Let no teacher of elementary arithmetic think that her work is not basic. The ability to perform accurately and expeditiously the fundamental arithmetic operations is an incalculable asset in the study and pursuit of science. Ease in the use of fractions, power of quick mental conversion from common to decimal fractions and the reverse, perfect familiarity with the language of variation and the statement of proportions,—these are much more important and also much rarer than one might suppose unless he has heard the complaints of teachers of the sciences. I have had occasion to give an elementary course in the mathematics of investment; the binomial theorem and geometric progressions dominate the theory.

My point is simply this, that there is no mathematics too elementary to be basic in the sciences. I do not propose here and now a catalog of the applications to science of the various processes of the more advanced branches of mathematics. I prefer to direct our thought to the question, "Why is mathematics basic in the sciences?"

The broad answer is that mathematics is basic in the sciences because mathematics is a language in which science can express itself. That which characterizes science is its constant striving to classify, to correlate, and to interpret what it observes. That which characterizes mathematics as a language is its precision, its unambiguity, and its coherence. Essentially then to be logical is to be mathematical, to speak exactly is to speak mathematically. This is not mere mathematician's boastfulness; it is a definition of mathematics.

But there is a finer reason yet, I think,

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why mathematics is basic in science. Not only is mathematics the language in which science can speak, it is the language in which science can *think*. I suppose some sort of language is necessary to any thought but certainly not all language provokes or encourages thought. There are forms of language which impede rather than promote thought, such, for instance, as the poverty stricken vocabulary of the profane or the effervescent vocabulary of the garrulous.

The use of mathematics as a language requires thought but it also greatly aids thought. The history of scientific thought and discovery shows how often great advances have had to wait on the discovery or invention of more powerful mathematical symbolisms. It shows, too, how often mathematically guided thought has outstripped experiment and experience. The wireless and radio were inevitable after Clerk Maxwell had built his electro-magnetic equations, but we had to wait many years for the laboratory to catch up with the implications of his thinking.

Someone has suggested that mathematicians have hindered science by imposing their forms and restrictions upon it. Well, when one begins to philosophize he runs the risk of saying clever things which are not so. Mathematics, as such, has no prejudices. It is entirely willing to adopt new symbols and new processes, but it does demand clear statement. It cannot abide vagueness or vagary and hence it stimulates clear thinking and urges one who takes the trouble to state his observations accurately to follow on whither they point.

Does nature obey laws? On this point there are sceptics who have become quite vocal. Some say there is no law for the individual but a strong probability for the group. Very well, says mathematics. If there is no law, at least there are facts. I should just as soon state facts as laws and I am as ready to formulate a calculus of probability as one of inevitability. If we push scientific indeterminism to the limit and decide that there is nothing we can safely expect, I daresay mathematics will be the preceptor who will teach us how not to expect.

It is possible to overemphasize the power of mathematics as a tool of science. May I mention briefly some of the limitations of mathematics in its application to science?

First there is the difficulty of measurement. All our units are artifical and where they have a natural basis, nature seems to abhor commensurability. If the day is a unit, the year is incommensurable. If the yard is the unit, the meter is incommensurable. We are constantly forced therefore to put up with approximations, and it frequently happens that the various measurements entering the same problem are not obtainable with the same degree of accuracy. And then there is the ever recurring transcendental, the $\Pi$ of geometry, the $e$ of analysis.

Then there is the inadequacy of the machinery of mathematics. There are notational difficulties which cramp our technical processes. The more powerful of our processes are relatively new in their techniques. Co-ordinates have been in use some three hundred years. Calculus is in its third century. Vector analysis, tensors, the mechanics of relativity are of recent origin. With every increase in the number of variables or in the number of assumptions there is a rapidly increasing difficulty in the technique. And new problems present themselves for solution faster than mathematicians can devise new methods of attack upon them.

Mathematics often presents us with an embarrassment of riches in its ambiguity of solutions. The quadratic equation has two solutions, the cubic has three, the inverse trigonometric function infinitely many. It is as though we had started a detective out to find a culprit and he had rounded up two or three thousand and said, "There's your man, in there." Differential equations, which deal with dynamic rather than static situations, have whole families of solutions and the solution which fits our case can be singled out only by knowing the so-called initial conditions of the problem. That is to say, after the mathematician has done his best, he must turn the problem back to the laboratory. The needle is still in the haystack, but at any rate we know which haystack to search.

And then there is the personal limitation upon mathematics in its application to science. It must take its material from fallible sources. The scientist, all too frequently, is not master of the mathematical machine in any such sense as he is of his reagents or his coils or his lenses. Then too there is the visitation upon the children of the sins of the fathers who have tried to teach science without mathematics. There is a high powered car at the laboratory door but the scientist has not learned to drive and he cannot always pick up a competent mathematician who has time to chauffeur for him.

Finally, there is the limitation inherent in the nature of mathematics itself. So many people think mathematics can do anything. But in a very real sense mathematics is non-creative. Mathematics is essentially concerned with transformations; its conclusions are inherent in its assumptions. However marvelous seems the mathematical machine to those who stand in ignorant awe of it, it is really no churn which can produce butter if you have put in no cream. Or, to change the figure, if you expect to get a rabbit from the magician's hat, you must first put the rabbit in the hat.

Thomas McNider Simpson, Jr.

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A truly enlightened mind is all the simpler for being enlightened and thinks, not without a modest sort of irony, that art and life exist to be enjoyed and not to be estimated. Why should different estimations annoy anyone who is not a snob, when, if they are sincere, they express different enjoyments?—George Santayana.

# SEARCHING THE SCRIPTURES

Ye search the scriptures, because in them ye think ye have eternal life; and these are they which bear witness of me."—John V, 39.

THE words as read may seem a little strange to you, because in the more familiar King James version they read, *"Search* the scriptures, for in them ye think ye have eternal life; and they are they which *testify* of me."

I have given the revised reading because I believe it to be a better translation, and because it better conveys the spirit of the Master as He spoke the words. He would approve, I have no doubt, the *imperative* "search ye"—the charge to read the scriptures—He *certainly* did so by His own example; but this did not happen to be the thing that was uppermost in His mind at the time.

He had done a notable healing which happened to be on the Sabbath day, and the leaders of the Jews were immediately up in arms against Him. They hated Him, anyhow, were deeply jealous of Him, and they used this literal breach of the Sabbath commandment as a pretext to persecute Him and to try to compass His death.

He answered with a reference to God as His *Father;* and then they were all the more embittered against Him, because they said He had made Himself equal with God, thereby becoming a blasphemer. He then entered upon a long defense of the *relationship* and of His work justified by it, in which He turned against His accusers as evidence for Himself one of the objects of their highest veneration—"Ye search the scriptures, because in them ye think ye have eternal life; and these are the very writings which bear witness of me."

"Bible Sunday" in our own Church, and now "Universal Bible Sunday" by common consent of the other Churches.

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A sermon delivered at Emmanuel Episcopal Church, Harrisonburg, on December 6, 1931.