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## SCIENCE IN CIVILIZATION AND SCIENCE IN EDUCATION

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To those of the teaching fraternity who believe that science is not fulfilling her mission as an educative factor in our schools, the ideas that follow are presented for consideration. It is not claimed that they offer a complete solution of the difficult problem before us; yet they may blaze a trail that will be of service to us eventually in finding the lost path, and in leading us to discover the hidden educational treasure.

The first idea to which attention is directed is that of the analogy which seems to exist between the development of the individual and that of the civilization in which he grows up. This concept has proved fruitful in many an educational problem; why should it not help us in our perplexities about science? May we not, from a study of the services which science has rendered to civilization as a whole, form some sort of a general notion as to what she might do for each and every individual? Let us see.

When we seek an answer to the question, "What has science done for humanity?" we find many answers ready for us. Prominent among these is the opinion that science is the cause of our great achievements and of our magnificent progress. We are told that we are better than the ancients, because of the greater control which science has given us over the forces of Nature. Can we not fly across the country at the rate of a mile a minute in what Mr. Dooley appropriately dubs "a rolling home of bliss," and thus spend one day in New York and the next in Chicago? Nay, science has taught us better than this. We can sit comfortably in our steam-heated offices and actually talk to our partners anywhere in the country about our next "business" move. Truly, science has taught us to do in five minutes what it would have taken the ancients weeks to accomplish. Thus science is the cause of this our increased happiness: bravo to science! It was well done.

And in fact, when we come to consider it, the external results of scientific work meet us at every turn. We are dependent every instant of our lives on science for our personal safety. What if our houses were not well constructed? And how do we know that the bridge will support our train? Everything about our dwellings, from the electric lights to the cement floor in the basement, owes its perfection to science. The labors of science have rendered us at one with the world—at least externally—for our newspapers keep us hourly informed of all important transactions that are taking place anywhere on the earth. Yes, truly, we live in a scientific age, since everything about us, excepting our own persons (*mirabile dictu*), bears the thumb marks of science.

Now if science has been and is of such tremendous importance in the life of civilization, and if there is an analogy between civilization and the individual, why does not science play an equally important part in the schooling of the growing man? Look at the requirements for college graduation and you will find that most students become bachelors after having devoted less than one-tenth of their total study time from the kindergarten on to science, including mathematics. How can such as these ever hope to catch up with the civilization about them? And what excuse have the schools for branding as educated such semicivilized beings? Such questions as these must occur to everyone who considers carefully the present educational situation in the light of the relations between the individual and his civilization.

But if we examine in this connection the statistics of the schools, and note how science is avoided when there is free election, we must conclude that the fault lies with the science instruction rather than with the schools. For science seems to glory only in its achievements and results, and this all-too-prevalent idea of the service of science to humanity is—alas!—being used as an ideal for science in education. According to it, every child must be taught to comprehend only the external details of his scientific environment and to know the principles on which steam engines, dynamos, telephones, etc., work. If he does not know at least enough about these scientific surroundings of his to be able to read the daily papers intelligently, science has missed its mark—so they tell us—as an

educative factor in his life. While this is true as far as it goes, is it all? Has science no other mark which has been missed, even though the one just mentioned has been hit?

Perhaps another will appear on further consideration. When science helped civilization to better means of transportation, what was the chief characteristic of the service? Is there any one element which appears prominently in everything that science does? When men first began to trade and to expand their physical and mental horizons, who but science taught them how to cross the seas? And when trade increased and population extended over the greater part of the globe, who but science showed them how to improve their ships so that greater returns were obtained for the same output of energy?

When health is considered, has it not been characteristic of science to show us how to improve methods of life, so that we now understand the requirements of healthy living, both as individuals and as communities? So that again we may recognize it as the function of science to develop better methods and processes and to teach us how to use them.

In the field of agriculture the same thing is true. For here too we note that the scientific study of this subject has gradually developed better methods of farming, so that we obtain larger crops from the same amount of labor; not to mention the reclaiming of tracts of land which were formerly considered as hopelessly barren. These results also have been attained not so much by applying to the problem the results of scientific work, as by attacking it by the methods invariably used by science, and in which her essential power lies.

Hence, when we consider the progress of civilization from the material side only, we must conclude that the service of science consists primarily in furnishing better methods and processes, which lead to the results attained, rather than in merely getting the results. The methods and processes are the causes of the results, and hence they are the more fundamental. So if we would render science more vital and make it a greater power in education on the external, material side only, we must pay heed to the methods of science rather than to its results.

And this means that we must forsake that definition of science which states that it is classified or organized knowledge. For these terms are in the past tense, and they carry with them the idea that the work of science is in the past, and that it is only with the results of that work that we have to deal. These definitions make of science a large museum of classified and organized facts, carefully arranged in glass cases, each of which bears prominently the inscription, "Hands Off." The student is invited to inspect our collection, and to learn the names and order of our well-arranged curios; but he is not as a rule asked to take part in their organization, nor is he even given a chance to find out what the methods and processes of such organization are.

This acceptance of the results of scientific work as constituting science is surely one of our grievous faults. For science is not classified knowledge—a completed thing; but rather classification or organization of knowledge—an active process. Therefore, if we wish to rescue science from its present decadent condition, one of the first steps seems to be the recognition of this distinction. And it is just as easy to present science to students from one standpoint as from the other. We have only to arrange the material so that each fact appears as a step in the process of obtaining a more general result, instead of presenting it as a separate and distinct result by itself. Then science appears as an organizing process rather than as an organized result. From the point of view of the learner, this change is all-important; for he then acquires from his study organizing power instead of memory drill—and it is primarily this organizing power of science which has made it a faithful servant of civilization. Thus science can best serve the individual if it follows a similar course in his case also.

But science has done more for civilization than to furnish it with better methods and processes of utilizing the forces of Nature for the physical comfort of men. It has played, and is even now playing, an even more important part in their intellectual and spiritual life. Perhaps the first point that strikes us when we take up this difficult question is that the worldly achievements of science have little or no bearing on man's intellectual and moral advancement. This idea is so firmly rooted in the minds of some of our best educators

that they go so far as to claim that we of today are intellectually and morally inferior to the Romans of the Augustinian age. It is true, they say, that we have greater physical comfort, but this is but dross: the real life is within, and there we have gone backward. Our scientific attainments have hampered rather than fostered our spiritual growth, for we have come to glory in external achievement rather than in inner excellence.

The fact that such opinions as this, ungrounded though they really are, exist must be placed to the discredit of science as an educative factor. Only those who have studied science far enough to realize wherein her great excellence lies will readily see the reasons for her failure here. But the great majority of people study only the elements of the subject, if they study it at all, and the elements are presented without any regard for the greatest of science's services to humanity, namely, these very intellectual and spiritual ones.

If we would comprehend what science means in the intellectual and spiritual growth of civilization, we must first recognize the fact that science has not been imposed on us from without. It is not a vast system of organized material which stands apart from us to be recognized or not as we may see fit. Science is a product of the human mind, and it has developed gradually with civilization and owes its origin and growth to the insatiable hunger of the human heart for unity—truth some prefer to call it. In its efforts to satisfy this hunger science has been developed—not a body of knowledge organized and mummified—but a power of organization; for, as has been shown, science consists today essentially of such methods and processes as have been found by a long process of trial and improvement to be competent to lead to results that more nearly satisfy our hunger for unity than do those otherwise obtained.

In this process of development of science, a number of intellectual and spiritual traits have been proved to be essential to success. Prominent among these is open-mindedness. No one can be said to have acquired even the elements of the scientific organizing power who has not this characteristic well developed. Yet does elementary instruction in science tend to emphasize this point? Consider the elementary texts of physics, for example. Do any of them allow

the student to think that any interpretation of natural phenomena is possible save that in the book? Are they not all as dogmatic as any religious creed that ever was invented? And yet this glaring violation of one of the most prominent of science's virtues is not in the least necessary, since it is just as easy to show the student that several opinions are possible, but that the one at present accepted by scientists is so because it seems the simplest and most satisfactory in the light of our present knowledge.

Closely allied with this open-mindedness is the recognition of the freedom of the personal judgment. This is one of the most valuable characteristics of science, for without it progress would be slow. And hand-in-hand with this goes tolerance, or respect for others when they exercise their personal judgments freely. Yet in elementary science the poor child is seldom given a chance to use his personal judgment—much less is he trained to use it freely. Small wonder then if even great scientists show streaks of marked intolerance.

Humility and reverence are also characteristic of the true science. And yet science in education not only does not foster these traits, but generally develops their direct opposites, so that we hear much ranting about the greatness of science and of her deeds. Many other noble human qualities which have been developed through science into powerful factors in civilization, but which do not appear even implicitly in the science of the schools, might be mentioned: such as justice, the conception of true freedom as harmony with law, and the ability to see things in perspective, or the relating power. But enough has probably been said to show how science in education has nearly if not entirely ignored them all. In so doing she has failed to do for the individual what she has done for the race. If science were completely to fulfil her mission to the individual, many of our most perplexing political, social, and economic problems would no longer exist.

Such are a few of the reflections that must occur to everyone who surveys science in education from the point of view of science in civilization. And as we ponder them, can we wonder that our youth turn from science without regret? What do we offer them of the many good things we might lay before them? When humanity

has shown itself capable of developing this powerful organizing process for the purpose of satisfying its hunger for unity, how do we science teachers dare to go on feeding to the children nothing but husks? Surely it is because of our ignorance. Yet is it not about time that we waked up to our possibilities? The coveted results lie within the reach of every one of us. We need no new laboratories, no new apparatus, no new equipment for the work. All that we need is a new method of presentation, and this every one of us has within his power to acquire. We have our guide and model in the service of science to civilization; why wait longer to begin?