Introductory Remarks

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● GOD CREATED the unit, the system, with its infinite number of aspects and interrelationships. Man, trying to understand God's creation, has as his only tool his limited mind. This tool varies from person to person in type and degree of refinement. Paraphrasing the words of the Earth Spirit in Goethe's Faust, it may be stated that our mind understands only those aspects of the world around us to which it resembles or whose basic theoretical structures are already performed in it. Hence, the work of many different minds is required if one wants to collect pertinent information on a complex natural system and to organize it into a body of knowledge that is at once sufficiently comprehensive to satisfy the searching mind and sufficiently detailed to be practically useful.

Water and soil are not only the most important materials in this world, but also the most complex ones, each in its own category, water as a liquid and soil as a multi-phase dispersed system. As a matter of fact, this very complexity of water and soil is the reason for their importance in engineering as well as in biology. If water and soil are combined to moist soil systems, then the complexity of each is multiplied by that of the other. At this point, the learned coward gives up; the conscientious scientist and engineer goes on. He observes and describes his observations; later, he classifies and systematizes facts found by himself and others; still later, certain simple mechanisms can be recognized and, if they are simple enough, be described by means of mathematical formulae. The total complexity, however, remains and any theory or hypothesis that is sufficiently simple to permit mathematical formulation is either so general as to be obvious, or it is applicable only to a limited area of the total field.

With the conscientious scientists and engineers go many others. The fools, of course, we shall always have with us, as well as those that want to be fooled. We have the impatient intellectuals that escape into theories in order to avoid the complexity of reality and then attempt to force reality into the straight-jacket of their premature creations. Then, we have the fellow-travelers that put their trust in formalized methods rather than in observing and thinking. Still, there are many well-trained, able and conscientious men working quietly on the soil-water problems. The best of them know that in order to make real progress in a chosen field of research, a man must first be true to himself; he must reproduce the world in his own mind and according to the structure of his mind.

Progress in knowledge is made by scientists and not by science. There are scientists whose minds approach the purely intuitive type, and others that are almost pure analysts. There is the majority whose mind partakes of both intuition and analysis in the wide range between the extreme types. There are scientists in whose memories can be stored a tremendous number of facts that somehow order themselves into structural units of connected knowledge, and others whose memories may hoard the same facts, but these remain inert and never enter into fruitful mutual relationships. There are men that have practically no memory, but possess a discerning and dissective genius that can detect the flaws of a mental construction if placed before them. All types of creative minds are needed in order to produce a mental facsimile of the phenomena that is wanted to understand and use for the benefit of our fellow men.

Much loose thinking and talking is currently going around about science and science education. The great present danger of this is that seductive half-truths may crystallize into legislation and further impede our scientific and engineering advance. Most of the proposals forget that it is man who makes science and not science that makes man. Man has been aptly described as an animal that has his head among the stars and his feet in the mud. This description highlights the glory and the tragedy of man, but it should not be forgotten that head and feet are only extremities of a physical, intellectual and spiritual unit in which balance and equal development of all parts is the prerequisite for harmonious functioning. Science, too, consists not only of head and feet, but must have a well developed body if it is to be of greatest use. This body must include all pertinent knowledge in a given field, the qualitative, the semi-quantitative and the quantitative,

to our present living science. The danger of doing this is real and present. As a result of the widely spread misconceptions about science and scientists, the creative scientific thinker, who grappels with problems too complex to yield to simple mathematical formulation, either by himself or by others, is being pushed out of the serene atmosphere of the basic sciences, and is supposed to join the ordinary inventor of gadgets and patent medicines in the noise and squabble of the market-place. Qualitative thinking, the thinking in picutres, or the geometrical thinking as Poincaré calls it, which is the prerequisite and first step in scientific discovery and invention, is being discouraged, and this under the pretense of doing something for science. It is high time that there is an understanding of science as it really is—a search for truth in which a man uses all the knowledge and all the material and mental resources at his disposition and in which the means of attack and the formulation of the results vary with the nature of the problem and its understanding by the scientist. This formulation shows the kinship of science with philosophy and art, in short, the kinship of all analytical and creative human endeavor to understand the world around us and to give expression to this understanding. In order to have more creative scientists in the future, there must be an improvement in the education of our present youth not only in science, but also in philosophy, in the arts and in the humanities. In addition, the illusion of a germane relationship between mathematical and general scientific talent and creativeness, must be erased. In so doing, the ability to detect in our country much more scientific talent and, possibly, even genius than suspected, would be greater. The wholehearted admission of gifted qualitative thinkers into scientific research presupposes, of course, that their ability to think qualitatively has been proven by education and performance and not just by a lack of gift in mathematical thinking.

Three years ago, the Committee on Physico-Chemical Phenomena in Soils of the Highway Research Board decided to bring together in one place as much pertinent knowledge on water, its interaction with solid surfaces, and its conduction in soils as could be collected by reasonable effort. This information was to represent as many facets of the soil-water problem as possible and, at the same time, as many different approaches as have yielded good and usable knowledge up to the present time, with the approaches ranging from the purely descriptive to the highly mathematical.

The Chairman of the Committee on Physico-Chemical Phenomena in Soils was authorized by the Committee and by the Highway Research Board to ask individual scientists and engineers as well as research institutes that have established reputations in the areas to be covered by the Symposium for contributions that would represent either original work or concise appraisals of the knowledge available in a specific scientific area. Worldwide representation was sought and a certain overlapping of treatment was considered desirable because of the complexity of the problems and the natural disagreement to be expected under such circumstances. In fact, it was reasoned that juxtaposition of contrary points of view in the printed symposium and their discussion would help to define and ultimately resolve areas of controversy.

It seemed desirable to have the entire publication in English; however, in order to alleviate the burden of contributors not fluent with this language, it was decided to accept also papers written in French, German, Italian, Portuguese and Spanish, to have such papers translated into English by the Chairman of the Committee and to print these translations only after they had been checked by the original authors.

While this undertaking was planned as a symposium-in-print, three opportunities were made available for personal presentation or summarization and discussion. These were as follows:

1. A meeting in the Building Research Laboratories of the National Research Council of Canada in Ottawa, October 9, 1957. Contributors able to attend this meeting presented their papers in person, while papers received at that time from contributors unable to attend any of the meetings were read by the Committee Chairman.
2. Two program sessions during the 37th Annual Meeting of the Highway Research Board in Washington, D. C., January 7, 1958, for formal presentation of papers and a committee meeting on January 6, 1958 for complete or summarized presentation by the Chairman of papers from contributors unable to attend.

the wealth of material properties and phenomena and the central nervous system of mathematical theory.

Now, some vociferous single-trackers want to create a central nervous system without a body and feed it with special food like a queen bee, with lesser nourishment provided for the common workers in the hive. Mathematical talent is to be the criterion by which to recognize and select those that are to become our future scientists, who are supposed to restore our leadership in those scientific and engineering fields in which we have lost it. The truth is that overemphasis on the theoretical and mathematical aspects of science and insufficient cultivation of the more qualitative and of the experimental material phases in American science education are among the major causes of the present deplorable situation. In freshman physics and chemistry, we have been teaching theory before the students were made acquainted with the actual phenomena whose explanation and correlation is the noble and extremely practical task of theory. Instead of introducing the students first to the living body of material phenomena and teaching them observation and experimentation until the mass of accumulated knowledge is too much for the memory and cries for organization by abstraction and theory, they are given a skeleton of abstractions and expected to put on it the flesh of reality. It is hoped that they will recreate God's work from the meager condensate of the abstractions of man's limited mind.

Natural science is based on observation and experiment; this basis has been more fruitful in providing real and useful knowledge than the purer thinking of the scholasticists. Should this proven basis be left for a new mathematical scholasticism? These comments should not be construed as an attack against the wonderful science of mathematics, the inventions of which may range from esthetic creations of the beauty and balance of a Greek statue to extremely useful and dependable tools of the natural scientist. Rather, they are made for the purpose of extricating mathematics from an imposed role of being either the highest form of natural science or the only acceptable language, and, at the same time, only a language of natural science. The real place of mathematics in the scheme of science, philosophy and art has been discussed beautifully by Poincaré in his popular writings.

Much misunderstanding is abroad, also, on the place and function of theory. Theory comes from the Greek word for "seeing". After contact has been established between a human mind and a physical phenomenon, the first step towards its explanation in terms of a more abstract body of knowledge is the qualitative or intuitive "seeing" of a correlation or mechanism. If the picture seen is very simple, a mathematical formulation may suggest itself immediately; if it is more complicated, but still relatively simple, one may find a formulation fitting the case among the inventions of the pure mathematicians, or the physical problem may stimulate a Newton to invent or develop a new branch of mathematics. Sometimes the picture is so complex that it does not yield to mathematical treatment. Whatever the case may be, the mathematical formulation, though of tremendous value because of its "correctness", represents a training and dressing up of the "new baby" to make it more presentable in scientific society, but is of itself hardly ever of the essence of discovery and creation in natural science. On the other hand, mathematical formulation of a theory can make it more precise and more useful and is something definitely to be desired and earnestly sought.

However, it should be remembered that mathematical genius or even talent is not a prerequisite for creative genius in natural science. This is well shown by the great discoveries in natural science by people devoid of mathematical talent. Nernst, the father of the heat theorem, is reported to have said that: God had favored him with such an intuitive understanding of the physical world that it would be immodest to ask for mathematical genius in addition. Voltaire, who had considerable mathematical talent, used it well to spread the new Newtonian physics in France, but did not add to it; while Goethe without such talent could not understand Newton, but in trying to refute Newton's color theory, did enough excellent observational and experimental work and thorough qualitative thinking to become one of the founders of physiological optics just as he was one of the originators of philosophic botany and osteology.

Favoring only the mathematically minded in our science education will deprive us of a large and important section of creative scientists of a type that has contributed much

3. A final committee meeting at Princeton University on April 2, 1958 for presentation, summarization and discussion of papers that became available after the Highway Research Board Meeting.

The area covered by the symposium may be divided into four parts, as follows:

1. The properties of the water substance which must be known before any real understanding can be attained of the behavior of water in soils and similar porous hydrophilic systems.
2. The interaction of water with solid mineral and organic substances, normally found in soil and in living systems, knowledge of which is basic for an understanding of the phenomena that occur in these systems and that are decisive for the life of individuals and nations.
3. The response of soil and similar systems to the application of physical and chemical potentials, and the movement of water as a resultant phenomenon.
4. The application of the collected knowledge to the rational design of highways and similar structures.

There is an old designation at German Universities that includes all members of the academic community from the president, or rector, to the greenest freshman. It is "Kommilitone", or fellow soldier in the search for knowledge and truth. The term is so old that it can refer only to the patient and enduring foot soldier, not to the dashing cavalryman or the modern bird man. This term "Kommilitone" seems to be most fitting for those that have contributed to this symposium. They are devoted and proven scientists and engineers who in their work and search have learned to appreciate the great complexity of the phenomena occurring in soil-water and similar systems and who have become aware of the limitations of their own knowledge and of the need for exchange and pooling of knowledge. They have produced this symposium as humble searchers and workers without fanfares or festivities, and without special appropriations, just adding one more task to their other toils. Speaking for them as just another Kommilitone, I should like to conclude these introductory remarks with the following credo:

"We are not aristocrats that believe in science for the sake of science alone. We are humble searchers for the truth, which is at once beautiful and useful. We hope to have approached this truth sufficiently that our work will be useful and an aid toward solving the many important water problems in engineering, agriculture and other human activities. We hope that our efforts will lead to a better life for all and especially for the humble people of this world. May God bless us in this undertaking."