

## PRESIDENTIAL ADDRESS

### “WHEN ARE WE SCIENTIFIC?”

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No one will question the statement that frequently there arises in the mind of the undergraduate and graduate student the inquiry: Where and how does this particular day's work fit into the pattern of thought and learning? Related to this inquiry is a second one: What are the tests to which this work must be subjected in order to judge the quality of its truth and worth? The fact that these questions arise in students' minds has not been given adequate attention by teachers to whom the training of youth has been entrusted.

If professional people will keep these ideas in mind their own methods of thought will be improved and they will frequently correlate the specific task with the larger problem, thus maintaining perspective for those with whom they work.

The mental concentration necessary to the successful completion of an immediate problem frequently excludes a grasp of that whole of which the day's work is a part. Thus perspective in thought, freedom of spirit, and incentive to enthusiastic action are lost. The exploration of a single, minute island of thought is likely to delay, if not prevent the discovery of the archipelago of knowledge. Circumstances and habit tend to confine our thinking within rather limited areas. It may prove interesting and profitable to detach our minds from the specific problems in which we have been interested today and review some of the broad premises upon which research depends. As a revered graduate school instructor was accustomed to say: "The review of an old problem along distinctive avenues of approach is constructive and creative thinking." I have no hesitancy, therefore, in directing your thought to an old, yet ever-new problem—"When are we scientific?"

The primary function of this paper is to raise the questions: Is a scientific method in one field of thought necessarily a scientific method in another? Are the criteria of scientific quality in one field of learning the criteria of truth and reality in all fields of learning? My tentative answer to each of these questions is "No." Are there specific tests of reality that are intrinsically a part of one field of thought that are not tests in another field? My answer is "Yes." Furthermore, these tests are the critical tests of scientific quality in the specific field. The intent is to direct attention to the fact that scholars researching in any field become convinced that their thinking and experimenting are scientifically done. This attitude of mind possesses distinct merit. Unfortunately they unconsciously draft the corollary that they have devised the only scientific method. This is an unscientific deduction. As a mother looking fondly at a passing regiment said: "They are all out of step but our son Jim."

The indiscriminating use of the terms science and scientific has contributed a great deal of confusion to our thinking. The evolution of the physical, the biological, and the geological sciences has so dominated thinking that whenever the word "science" is used there is a connotation that the reference is to one of the above sciences. A concomitant error is involved in the use of the word "scientific." Unintentionally the methods of investigation and the criteria of validity employed by the physical, biological, and geological investigators have been accepted as inseparably associated with, if not the embodiment of, scientific thinking. This persistent association of the word scientific with those sciences is unjustifiable. "He is a scientific thinker" is a typical use of the word and connotes something infinitely more than compliance with the techniques of the physical sciences. As thus used the true meaning is that the worker subjects his information to those tests of validity that are of the essence of the information with which he is working, and that he subjects his methods to the tests of rectitude intrinsically associated with a specific field of thought. These tests are not necessarily the measures of scientific quality employed in physics, chemistry, biology, or geology. A deliberate effort should be made to divorce the word "scientific" from the implied relation to the sciences: physics, chemistry, biology, and geology, except when designating the quality of the work done in these subjects. There are accurate and valid tests of the quality of the information and of the methods of thinking in history, geography, theology, and philosophy, that are as scientific for these fields of thought as are the accepted tests for physics for that subject. That some of the tests are valid in several fields is a reasonable assumption, but it is just as reasonable to assume that there are inherent tests for a specific field which are not common to any other field.

The above use of the phrase "fields of thought" is an attempt to limit the discussion of the question "When are we scientific" to categories and thereby simplify the problem. There is an infinite number of subjects of thought, but since the universities and the colleges have organized their curricula upon a group or division plan, it is reasonable to assume that there are inherent likenesses and similarities running through the subject matter and methods of thinking employed in a group. If such is the case a list of the tests of scientific quality derived for a subject such as physics, will be typical of, and applicable to, that field of thought commonly designated as the Physical Sciences. Furthermore, defining the tests of validity of information and the methods of thinking in a subject such as geography, in the social science group, ought to establish the criteria of scientific thinking in the social science field and thereby define the major criteria of scientific thinking in history, biography, economics, geography, political science, sociology, and psychology if it is classed as a social and not a physical science. Thus the limits of the problem are narrowed and a survey of the question "When are we scientific" may be confined to two of the five or seven groups generally outlined in college catalogs.

The primary premise is: Each field of thought possesses criteria of truth inherent in, and organically a part of it, which are the essential

measures of its scientific quality, but not necessarily tests of validity in other groups. If this premise is tenable, then a catalog of the criteria in each field should be made. Any scholar must accept the tests of validity recognized in fields other than his own if he wishes to justify his claim to scholarship in his own field. Furthermore, no one field of thought can impose its tests upon another field and insist that they be considered valid tests of truth thereto, unless they give evidence of belonging organically to the field.

I choose to undertake the study of the following two groups chosen from the college catalogs, in an effort to list some of the criteria of scientific quality of each:

1. Physical Sciences: chemistry, mathematics, physics.
2. Social Sciences: including biography, economics, geography, history, political science, psychology, sociology.

The principles of logic are universal prerequisites of scientific thinking. The syllogism, types of terms, definition, and classification, valid moods and other statistical forms, hypothetical and disjunctive arguments, analogy, and similar principles of reasoning are universal tests of scientific quality. They are not the specific tests by which scientific thinking in one field may be differentiated from scientific thinking in another field. The present quest is for those specific tests of scientific quality that characterize the physical sciences, but are different from the tests for the social sciences and all other fields of thought. The following two discussions attempt to segregate and catalog the tests for the physical and for the social sciences. It would be folly to claim that this treatment is exhaustive. The primary intent is to state a problem in an objective way.

Two lines of investigation have been pursued during the past two years in the search for definite statements of criteria of scientific quality of thinking in these two fields.

First: The dissertations presented for the advanced degree of Ph.D. in various institutions have been examined in search of some principles which were employed in testing the scientific quality of the research. It was discovered that the dissertations in any department are confined to a narrow field, and the dissertations directed by any one man are restricted to a more limited field. That should be the situation. A further examination reveals the fact that the method employed in the original dissertation, probably the director's own dissertation, is practically duplicated in the successive theses. Similar materials and identical or analogous circumstances have been introduced, but in reality there are no fundamental differences between problems. One of the striking illustrations is in taxonomic problems in biology. All that is to be found in these theses is an amplification of a problem previously explored. Such a discovery leads to the conclusion that well-defined tests of scientific quality have not been consciously employed, but that a pattern was constructed in the original dissertation and the scientific quality of successive dissertations has been judged upon the basis of how well they conformed to that pattern. All such research is commendable and certainly makes valuable contributions to knowledge.

The disturbing deduction must be that the "ruling theory" or "authoritarian method" of thinking has been the dominating test of scientific quality employed. Strange to relate, this method has been severely criticised by experts in the physical and biological fields when employed by investigators in other fields.

This line of investigation did not yield specific statements of criteria of scientific quality.

A second line of investigation was followed. A search was made in the books and journals that discuss methods of research, investigation, and thesis writing to locate, if possible, the criteria by which the scientific quality is judged. Brief references are made to the problem in the books and journals, but no inclusive catalog was found. The books of logic define clearly the principles of logical thought. However, it is not logic's function to define the basic criteria of truth and reality, or the scientific quality of thinking peculiar to a specific field of thought such as physics or philosophy.

With these two lines of investigation as a background the writer attempts to develop a brief list of the criteria of scientific quality for each of two fields: the physical sciences and the social sciences.

#### **Quest number 1—The Physical Sciences:**

Each of the so-called fields of thought is concerned in its own way with the interpretation of the world. Departmentalizing subject matter and collecting the departments in fields of learning is artificial and is a response to the limitations of the human mind which demands that knowledge shall be classified and cataloged. Classifying knowledge always suggests a simplicity that does not exist. Man thinks in types which represent ideal conditions. He infers that principles applicable to the type or type conditions are tests of reality for the group even into the twilight zone where the group amalgamates with other groups, or conditions merge with adjacent conditions.

Physics and chemistry deal with materials in terms of constants. Non-variability is a fundamental consideration to the physical scientist. He has constructed his method of investigation upon the advantage that non-variability gives him. In the words of Ritchie, "He assumes, for instance, that in considering a small portion of the universe he can neglect all the rest."<sup>1</sup> When he has finished with that small bit "He looks around and brings another small bit of the universe into his ken, and continues altering his field of observation until his isolated system behaves as though it were really isolated. All the time he is able to leave the whole universe as such, alone; he gets all the advantages he could have got out of a theory of the universe without the disadvantages."<sup>1</sup> Ordinarily he does not attempt a summation and to a much less degree an integration of the units.

Pure science deals with these isolated units. Probably the only distinction between pure and applied science is that applied science is concerned with the relation between the isolated units of pure science. Out of these inquiries of pure science emerge those criteria that are the bases for judging the scientific quality of the work.

<sup>1</sup>Ritchie, A. D., *Scientific Method*, p. 7.

Whether a piece of work is scientific or not in the physical sciences may be measured by the following tests:

1. Has the human factor been eliminated or reduced to a constant in performing the experiment and in recording results and observations?
2. Has the material or the action been resolved into a single isolated unit? Have the variables been reduced to one?
3. Has simplicity been attained?
4. Have the results been attained by both a direct and indirect attack, i. e., can the results be secured by a process of elimination, or as a residuum of the solution of associated problems?
5. Can the results be expressed in a mathematical formula of quantitative, not descriptive terms? Sumner has said, "Science is science—only insofar as it is capable of mathematical expression."<sup>2</sup> In the physical sciences, each function in the formula must be capable of calibration. There are some fields of thought in which the facts that determine reality are not amenable to calibration.
6. Any description of characteristics and interpretation based upon observation in natural settings must be checked repeatedly and confirmed in a man-devised experiment.
7. Identical results must be secured by independent investigators using the identical methods and materials of the original investigator.

There are three well-known methods of investigation:

1. The Ruling Theory—Authoritarian.
2. The Working Hypothesis.
5. The Multiple Working Hypotheses.<sup>3</sup>

The human mind possesses an irrepressible tendency to resist the invalidation of any explanation of a phenomenon that it has proposed. The fact that this tendency exists demands that some method of investigation shall be devised that will automatically annul it. Many people cannot say, "I do not know." They employ the "ruling theory" or "authoritarian method" in their thinking. This attitude of mind is a hangover from the day when a scholar could compass the whole of human knowledge, when most of the information and training were in possession of a limited few. The scholar then made plausible explanations of phenomena that were readily accepted as true. Thus developed the "ruling theory" or "authoritarian" process of working. As Emerson said, "We hate to think"—and hope that some one will save us that discomfiture by producing a formula for action. The investigator should be conscious of this tendency and devise methods to render impossible its practice.

The single hypothesis procedure possesses the same weakness of permitting men to give undeserved protection to a brain-child.

<sup>2</sup>Sumner, Frances B., *Scientific Monthly*, Vol. XXV, No. 4, October, 1937, p. 345.

<sup>3</sup>*Journal of Geology*, October, November, 1897, Chamberlin, T. C. Vol 5, No. 8.

The question naturally arises, Is there any method available which mechanically eliminates this tendency toward the expression of prejudice?" If such a device is available it ought to be discovered most readily in the physical sciences since they deal with the inanimate.

The "multiple working hypotheses method" utilizes the process of elimination to a high degree, consequently its use might be considered a criterion of scientific quality in investigation. Any one will acknowledge that building cognate hypotheses is difficult. Nevertheless there is merit in the severity of the task. As the investigator builds the several hypotheses he unavoidably discovers new ideas, observes new conditions and relations that he may not suspect exist when the authoritarian or single hypothesis method has been employed.

### **Quest number 2—The Social Sciences:**

Man and man's activities are the central ideas in the social sciences. These premises must be accepted when a question is raised concerning the scientific quality of the work done by investigators working in the field. The central idea is the interpretation of the responses of life forms to the social and physical environment. In his research work the historian, the economist, the biographer, the political scientist, is confronted with more than the immediate environment—he must deal with the biological heritage, the social heritage, the philosophy and experience of the individual as well as of the group of which he is a part.

The period when the major function of the historian, the political scientist, the economist, and the geographer, was fact finding and the recording of information is past. That was a very important period in social science history. The present is a period when interpretation is the major objective of research. This fact is of supreme importance and demands major consideration in any attempt to set up standards of scientific quality for the work done in the social sciences.

The ever-changing, dynamic world doctrine is generally accepted. This fact demands that some new criteria of truth, inherent in, and organically a part of the social sciences, must supplement the previously-accepted tests of the scientific quality of research. Furthermore, it is absurd to superimpose upon the man-centered social sciences the tests of validity of mathematics and physics which are primarily concerned with the inanimate. Those tests possess a limited application, but are not inclusive of all tests nor are they the fundamental ones.

May it be true that students of social sciences, education, philosophy, and religion permitted themselves to be hurried into changes of procedure by the success of investigators in the fields of physical science, biological science, and thereby became imitators when they should have examined their own premises and developed methods consistent with the inherent characteristics of their own fields.

Educational statistics exhibit, in a striking degree, the agonizing efforts a field of learning experiences when it attempts to ape the successful technique of another field of learning and to use methods that are not inherently applicable to itself. The formulae used in statistical methods in education are not formulae. Their symbols are not the

language of constants, but of variables that are wholly descriptive—not definitive. It is quite proper to use these formulae if it is recognized that the symbols represent descriptive terms. It must be recognized that they are not mathematical formulae—they just simulate formulae, hoping thereby to gain greater respectability in an age when an unjustifiable attempt has been made to subject all scientific quality to quantitative measures.

Man is a complex organism, the animate and inanimate environment in which he moves is complex, the parts inseparably interwoven and integrated—consequently it is impossible to set parts of the environment or responses off as units by themselves and deal with them as separate units as is done in the physical sciences. The very nature of the social sciences precludes the possibility of considering a small portion of the universe by itself and neglecting all the other parts. Consequently, we may be compelled to accept the training and character of the man who makes the interpretation as the best criteria of validity of thought. If such is the case, we must test the quality of his research by testing the researcher for his capacity to discover significant information and test the quality of that information; for his alertness to existing conditions, and logical, effective summarizing. Thus we arrive at the idea that there are at least two measuring scales by which we test the scientific quality of investigation in the social sciences:

First: We judge the quality of the research by evaluating the training of the writer. Is he trained in the mechanics of scholarship, i. e., trained in paleography, in lexicography, in rhetorical expression; is he able to analyze his premises and judge whether there is unity and continuity in his own thought and writing, as well as able to compare and contrast his work with that of scholars in the identical and similar fields?

Second: We judge the quality of the research by evaluating the personal qualities of the worker—his philosophy of life, attitude of mind, i. e., his sympathies, enthusiasms, personal interests, prejudice, envy, malice, his experience in the world of reality, and his ability to live successfully with men. This group of tests in reality is a test of the character of the worker.

The experience of the worker in the social sciences is a major test of the scientific quality of his work. There are two types of experience: actual and vicarious. To a degree it is possible for a geographer to be so thoroughly informed concerning the habitations, the tools, the religion, the social customs of a human group living a life of isolation in a dissected upland that he becomes a part of a Scottish clan that he may live, to a degree, the life of Scott's Roderick in the "Lady of the Lake," or, he may visualize the life of the mountaineer of our Appalachians until he can approximate the feud, blood-retribution spirit of the Hatfields and McCoys. However, his vicarious living can only approximate reality and the approximation of the reader of his description will be of lesser degree. The fact is that the vicarious experience of the reader of the geographer's interpretation can never equal actual experience. There is no subjectivity that can possibly replace objective experience.

It is difficult for us to accept these tests as criteria of scientific quality of the geographer's and economist's work simply because we have become so greatly enamored of the quantitative methods of the physical sciences and are suspicious of qualitative tests. Nevertheless, they are the specific tests of scientific quality in the social sciences simply because they are of the very essence of them.

The tests of scientific quality in the social sciences are at the extreme opposite pole from the tests of scientific quality in the physical sciences. They express a contrast that naturally exists.

In summary: Students classify their knowledge in compartments that have been designated fields of thought. In all classifications it is the ideal, representative subject matter and ideal method of thinking that are considered when the particular field is named. Little if any thought is given to the zone where one field passes indistinguishably into another field. There is subject matter and there are methods of treating information that are common to all the fields of learning. There are tests of scientific quality that are common to several, but not to all fields. The significant fact is that there are a few tests that are the specific tests of validity in a particular field and these are the tests that should be given the greatest weight in evaluating the scientific quality of the studies in that field. Helmholtz acknowledged the existence of this idea when he pleaded for an increased and closer connection of the points of view of the various sciences especially when these dealt with the same subject or similar subjects.<sup>4</sup>

If these specific differences can be clearly defined, scholars will have at their command the tools by which to judge scientific quality. Definitions can be made and when they are made scholars in any field will have at their command criteria by which to judge the work in that field. Possibly the day may come when the physical scientist will not accuse a worker in the field of philosophy and religion of being unscientific because he has not employed the tests of physics and chemistry in his work. When these definitions are made then students are going to acquire a finer appreciation of one another's work; are going to be more sympathetic with one another's endeavors; and are going to be more scientific in their appreciation of the whole rather than parts of knowledge.

This brief review of a problem is presented with the hope that other analyses may be offered and that both graduate and undergraduate students may be aided in their quests for statements of tests of scientific quality of investigation.

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<sup>4</sup>Jones, W. Tudor, *Contemporary Thought of Germany*, p. 129.