THE PHILOSOPHY OF SCIENCE: A COLLEGE FRESHMAN COURSE

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This paper will discuss three questions: first, why philosophy of science should be taught at all in the freshman year at college; second, what is the most defensible way of giving such a course; and third, what one should expect from such a course.

I. The common reasons for introducing a course in the philosophy of science—that it acquaints the student with intellectual procedures common to all the scientific disciplines, that it helps to break up the too-close adherence to textbook pronouncements which may have been learned in high school, that it introduces a set of concepts broader than any one science and therefore not repeating familiar subject matter—are good enough to make tentative introduction worthwhile. But there are counter-reasons which must be met and disposed of: the course may encourage superficiality, it may be prematurely introduced, it may be unfair to those students who have had little science in high school.

There are two phases in teaching the philosophy of science. Early efforts to encourage habits of reflective thought about the concepts, principles, and proofs of science become a different sort of task *after* the student has acquired some familiarity with the data and procedures of science. This familiarity makes him aware, as a matter of course, that first of all science has some kind of method, and that the proposed premises and conclusions of a science command a respect which propositions of everyday colloquy do not, even though the scientific statements may repeatedly be brought into question. But a freshman who has had very little mathematics and perhaps no more of the other sciences than a short course in botany or zoology or one of the social studies, is in a poor position to commence evaluating scientific theories. A course in the philosophy of science for the beginner thus holds two sets of terrors for all but the most sophisticated of students: the need to master, at least in a rough way, the *materials* or contents of certain scientific arguments, and the need to grasp their *form*. The content is the science, the formal analysis is the philosophy. Later work, for more sophisticated students, could take for granted the content.

Science on the one hand has a peculiarity stemming from the very assumption that it is more than mere guesswork; a given scientific proposition sounds as if it were universally true for all instances falling under it. And there is a presumed necessity that a scientific proposition relates logically to other such propositions. To these two claims the student all too often responds by feeling that anything which passes for science is indisputably true, that one might as well unquestioningly accept it.

On the other hand, attempts to philosophize about the fallibility of our senses, about the intrusion of possible errors in our reasoning, or about the ambiguities of language employed in communicating results of scientific investigation almost invariably lead the student to the opposite attitude. He is now inclined to view the pursuit of solid truth as hopeless, and to fall back upon pragmatic expediency or upon the popular consensus as the standard for accepting or rejecting scientific statements. In brief, the study of science from a *scientific* viewpoint very easily leads to dogmatism. The *philosophic* study of science frequently results in skepticism. A superficial acquaintance with the history of scientific ideas suggests a vast confusion, with sets of interpretations of the universe succeeding each other dizzily. This may not be a grave disadvantage in the long run, because a dogmatic opinion must have its own antidote; but in the short run it bewilders the beginning student and apparently undoes precisely what teachers of science are trying to accomplish. Yet — here is the main point — the proper introduction of just such a questioning attitude will benefit not only students going on to major in philosophy, but also those who expect to become scientists. Reasons for this should become clear in the final section of this article.

So much for generalities. I now wish to attach this discussion to an experience of my own in the teaching of the philosophy of science, because such experience is not simply an artificial construction, and has many implications for us all.

II. Any elementary course in the theory of science must, I think, assume little prior familiarity with the facts of science and its long and fascinating history. For a number of years, from 1954 until the spring of 1962, I had responsibility for the teaching of a course which met approximately 24 hours during the term, had no prerequisites, accommodated about 50 students, and which was much restricted in the textbooks it could employ, owing to the confinements of a book rental system. On the other hand, perfect freedom in the style and content of the course was granted, and supplementary readings were frequently mimeographed as adjuncts to the texts, the first of these being *Treasury of Science* edited by Harlow Shapley and others, the second a more conventional anthology, *Philosophic Problems*, compiled by Mandelbaum, Gramlich, and Anderson. I used lectures and discussions, and where possible introduced simple demonstrations supplemented occasionally by slides and short motion pictures.

A course of this sort must retain a certain freshness of treatment. This means that at least part of its content must be changed each time that the material is run through. Moreover, events such as the orbiting of the first satellite, the death of Einstein, or the latest medical advance may make it profitable to give more than passing attention to the principles involved in contemporary scientific theories and technics. Here the teacher of the philosophy of science has a considerable advantage over that of one of the particular sciences, namely that he can quickly adapt any event to suit the context. The death of Einstein, for instance, could hardly be genuinely pertinent in a class in botany, or chemistry, but it could quickly be made relevant to any discussion of motion, time, space, the application of mathematics to nature, the steps in scientific method, the apparent discrepancies between sense data and intellectual interpretation, the theory of measurement, the problem of truth, the sociology of the spread of scientific ideas, the refutation of formerly prevailing doctrines. These are not ideas which attach to any one science exclusively; they fit, because of their philosophical nature, in all of the sciences, in many individual ways.

This very sort of consideration was instrumental in determining the structure and method of the course. In planning it, I made a list of three dozen or so concepts which seemed of most signal importance in the sciences and in the study of their methodologies. In making this list, it seemed wise to give preference to those concepts which, albeit changing their meaning while they did so, turned up in a plurality of sciences. Thus "circle" is important in geometry, but not in elementary arithmetic, and it enters the other sciences—where it does enter—chiefly as a geometrical notion applied literally. So "circle" was left off the list. But "color" is of interest in physics, in psychology, and in sociology (as regards fashions of preference). The readings from Newton and others, and the very simple demonstrations of color perception carried on with the help of felt patches and slides were used to show the ways in which the optical problem and the psycho-sociological problem were partly the same, partly quite different.

Another basic term, or rather pair of correlative terms, is "part" and "whole," a pair which very elusively seems to require redefinition as soon as we pass from one science to another. Thus to say that an angle is part of a triangle is quite different from saying that the earth is part of the solar system, and this in turn is quite different from saying that the hand is part of the body. It may even be ambiguous to say that a toenail, a hand, and the lungs are all parts of an organic whole. At any rate, this pair of terms is one that must be carefully examined in a wide variety of scientific contexts, as should "finitude and infinity." The word "life" is seemingly of interest only in biology, but at least its meanings to a virologist, a parasitologist, a vertebrate embryologist, and a psychologist are sufficiently varied to be well worth the trouble of explaining. And so on for quite a sizable list, including "time," "space," "motion," "cause," "evolution," "machine," and the like.

But there was a second list, of importance equal to the first, which consisted of terms used *about* the sciences rather than *in* them: terms such as "inquiry," "probability," "common sense," "induction," "theory and practice," and others of this type. Such methodological terms, however, can no more safely be introduced to the student in absence of concrete illustrative readings and demonstrations than can those of the first class; and consequently there was no thought of beginning the course with them. Most often, some such terms as these served to conclude the work.

But of course it was impossible to pack all these terms, which ran to nearly forty, into a term (be it a quarter or even a semester) and still make them meaningful; so, each time the course was offered a drastic reduction had to be made, and each class embarked on the study of no more than four or five of them. Great care had to be taken to select a set that would not unduly penalize those who had had considerable biology but little or no physics, or who had had college logic and mathematics but no laboratory science, and so on. Accordingly, I generally chose notions for which the best illustrative readings were in one group of sciences, then in another and then still another. This made it advisable to discover what prior training the students had had; a show of hands was usually sufficient to indicate intended and declared majors, high school experience, and whatever else seemed relevant. Such a procedure had the effect, moreover, of keeping the work new and to some extent proportioned to the needs and aptitudes of each class. At the same time, the backlog of materials falling under each concept allowed a certain stability of organization. It is also interesting to note that some of the same little informal demonstrations could be used to point to more than one concept—for example these patches of felt which admirably exemplified the psycho-physical aspects of color could also be used to start a discussion on the pros and cons of a skeptical approach to the proposition that the reports of our senses are sure grounds for scientific knowledge. Perhaps this was being overly economical; but I should remind the reader that there is nothing so small as the budget for laboratory equipment and supplies in a department of philosophy.

III. My own view was that despite a good many limitations the course was a fair success, although it was eventually discontinued because of a university-wide change of the curriculum for all freshmen. It is hard to assess what benefits there were for the individual students, of whom there were about a thousand in all. The most exact estimation of the success of a course of this kind lies in exhibiting the basic principles by which instruction was carried on, and then asking how the methods of the course would comport with the aims. If we are to examine the sciences, or even a single science, we soon notice that our subject matter divides into statements of problems and statements of solutions. The history of science is such that the problems of one man are ordinarily not solved by the solutions of another—the first man would not concede that his quest had ended. We must view a scientist's problems and solutions in an orderly context, one that he builds up through the principles he selects, his illustrations, applications, deductions, conclusions, and further questions. This requires a careful appreciative reading of each man's text, and the awareness that the terms, propositions, and arguments must all fit together by a logic often dishearteningly peculiar to the writing under scrutiny. But through this close study of what a man says we can see the way he gives meanings to his terms, the kinds of truth, provisional or eternal, that he claims for his propositions, and the rigor he expects his proofs to exhibit. This effort to interpret the inner logic of an article or treatise is a more fruitful way to investigate scientific method than to rest on the dogmatic (and quite erroneous) assertion that every scientific work consists of four mechanically-arranged stages, or upon the remark that hypothesis is always prior to law. The student can come by this more flexible strategy to look at each piece of research or formulation with a new eye, and to discover what is truthful though perhaps embedded in what is partially wrong, vague, or nonsensical.

Differences in scientific conviction are not, as a rule, head-on oppositions. Only if a term is used unambiguously between two men can it be brought to flat contradictions. The successions of scientific ideas are based chiefly upon changes in terminology and hence misunderstandings, and although some scientific ideas are much better than others, it is not possible to classify them under the same logical headings, if only because their originators did not all learn logic out of the same book. A *tolerance*, then, based upon this sensitivity to the kinds of expressions of thought, should not be the least useful skill accruing from this particular philosophical approach.

The student, moreover, must learn for himself that although the scientist speaks in highly specialized language, he is also employing quite general concepts, such as those we listed earlier. When two taxonomists argue about rosebushes, they are concerned not only with the classification of these individual plants, but also with the very meaning of the concept "species." When Einstein asked whether space was limited, he was also asking for a meaning of the concept "limitation." It takes a nice eye for the student to see this, but if he be guided with sufficient care he can usually make fair strides in the direction, not of ordinary induction, but of a philosophic intuition which discerns the relation between a broad and a narrow concept. This may not be the interpretation ordinarily given of the nature of scientific thought, but this second skill in thinking, *intuitive exactness*, seems as much needed as tolerance, if we wish to study the development of scientific theory.

These are large aims indeed for an elementary course in the philosophy of science. On the other hand, why should we settle for substantially less among the intellectual virtues than the tolerance born of clearheaded insight?

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