"Lab"

THE EXPERIMENTAL aspect of science is its most distinguishing characteristic, and laboratory courses are the backbone of a scientific curriculum. There are certain factors, however, which sometimes tend to obscure this fact and to reduce the emphasis on experiment and laboratory work to the inevitable detriment of the quality of scientific instruction. This in turn reduces the extent to which scientific training can make its characteristic contribution toward the solution of any of the broader problems of society.

One factor which frequently militates against the extensive use of laboratory instruction is the lack of a really intimate appreciation of the role of a laboratory by non-scientists in academic administrations. If deans and fiscal officers and trustees are not themselves scientists or imbued with the scientific spirit they have to take the need for laboratory instruction on faith. In times like these when budgets are hard to balance the relatively high expense of laboratory operation comes in for close scrutiny. Another factor is that learning by observation is not innately congenial to many students. It is harder to dig things out for one's self than to be told them by someone else. Physical facts are hard and knobby things and a strenuous intellectual effort must be made to grasp them. It is human nature to entertain the vain hope that someone else can make this effort on your behalf and that the novel ideas and methods of science can be made an integral part of one's own intellectual equipment by proxy. The laboratory has real glamor only to the eye of the scientist, and the freshman, like the puppy, has to start life with his eyes shut. Neither is the life of the laboratory instructor easy and a young man fresh from the intellectual setting-up exercises of his PhD examinations is an easy prey to the specious argument that the "cultural" content of physics can be imparted in a lecture. What science can contribute to our culture is its method. No description of science be it ever so eloquent can replace actual grappling with the phenomena of observation for learning this method. As a result of such factors as those indicated above the number of descriptive courses which purport to tell about science is increasing on our campuses; this is a serious cause of concern to us all.

The good physicist is a respecter of the good experiment and the hallmark of a scientist is his recognition that critical first hand observation is the ultimate basis for authority. In a sense a scientific theory is a work of art and imagination; elements of inspiration underlie the nexus between diverse phenomena, and an austere elegance characterizes the ultimate simplicity of a theory when all extraneous and irrelevant considerations are shorn away. But to be scientific it must be in intimate contact at every point with the observations which each of us can make in his own laboratory whether in Europe, Asia, or Africa and whether our skins are yellow, white, or brown.

The structure of science has often been described with great insight and beauty in an architectural metaphor. Deep beneath this structure which is topped with the delicate finials of speculation and hypothesis one is aware of the massive solid footings of experimental fact and the deep pilings of critical observation which penetrate the treacherous morass of casual sensory perceptions and firmly support the edifice of science. The workmen themselves who mortise the stones and fit the timbers, though often distracted by their own ineptitude and the crudeness of their tools, have the most intimate appreciation of the structure that rises under their hands. But the studious visitor who sees the design with his own eyes and feels the smooth solid texture of the walls with his own hands is elated that this triumph of human science is in a sense his own. His respect for the

unity of concept and the skill of craftsmanship that it represents increases in proportion to his familiarity with the structure. However, the man who reads the story of the great undertaking or who is told in never so glowing words of its wonders and significance must content himself with a cloud castle which all too soon fades from his imagination.

The story of physics can indeed be made fascinating by a gifted lecturer, but it remains a story and the essence of science is not to be imparted in words. It must be gained in the laboratory where the phenomena themselves are seen and felt and heard and the ultimate incontrovertible authority of experiment is manifest. Words can be woven into beautiful fabrics of argument which gain plausibility by rhetorical skill and subtilities of intonation. Forensic adjuration can take on the very aspect of truth itself and be all the more misleading because it remains a mere windy dialectic without actual substance that can be grappled with and confuted. These farragos of prejudice and error which so often pass for logic in common conversation are the bane of the popular discussion of the major issues of our day. The greatest contribution that science has yet to make to society is not an improved technology but the extension of its technique for winnowing significant fact from the welter of confusing appearance by recourse to critical and dispassionate experimental observation. The laboratory is the place where this technique is displayed in all of its beautiful simplicity and to be learned by direct contact with the phenomena.

To learn physics and through it the scientific method it is not enough to be told about it; one must experience it in the laboratory. Though this view is commonly held by scientists it is by no means a universal one among educators. Unless one has oneself learned through personal manipulation and operation it is difficult to appreciate the full impact of the authority of facts. To the average person it probably seems self-evident that we know more about a chair than an electron. The reverse is obviously true to a physicist since there would not even be universal agreement about what constituted the definition of a chair, whereas an electron is a precisely defined entity upon which physicists all over the world are in complete accord. Precise procedural definitions of terms are learned in the laboratory and such definitions must form the ultimate basis for rational communication between men. The laboratory phase of instruction in science gives promise of possible extension to those broader fields of common interest where it is badly needed to dispel the many sources of misunderstanding and conflict which hamper human relationships.

There is of course a place for lecture and classroom work in science but in the heart of the curriculum these are subsidiary to the laboratory and the demonstration. In advanced courses the deductive argument often requires extensive mathematical development and disproportionate time must be devoted to it in comparison to the rather simple experiments to which it relates. In elementary courses the reverse is true; the concepts are more difficult to grasp than the mathematical techniques and if one is to learn physics the laboratory phase of instruction must be accorded the central place. Elementary courses without laboratory may not be without their value, but they are descriptive and expository stories about science and thus to be regarded in the same way as courses in the humanities which are primarily stories about people rather than encounters with the people themselves. What must be guarded against is tendering such courses as the true coin of science itself; this they are not for we must learn our science each of us individually from nature herself.

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