BASIC SCIENCE AND THE UNDERGRADUATE MEDICAL CURRICULUM

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Introduction; The Present Dispute

Current commentary on medical education is full of complaints about the basic sciences. These subjects are said to include too much detail taught in a dead, rote fashion. In their present form they bear little relation to the clinical work that follows them. Teachers and students alike lack enthusiasm; students wish to get on to the clinical subjects, and teachers prefer graduate students to medical students. If the present-day medical curriculum is too reductionist, overspecialized, and fragmented, the basic sciences are said to deserve much of the blame [1–8].

Contemporary critics propose various remedies; they suggest that the scope of the basic sciences be curtailed, that they be taught in an interdisciplinary fashion, and that they be taught at the college level and so eliminated from the medical curriculum in their present form. One proposed solution is to integrate them with analogous graduate school teaching. Others have favored less attention to content and more to problem solving and the experimental method, or ending the separation between basic and clinical subjects by interweaving both approaches throughout the curriculum.

Defenders of the basic sciences in their present form argue that physicians use basic science in medical practice (or at least should do so) and that, anyway, physicians must know scientific principles to avoid becoming technicians. Some even advocate aggressively expanding the basic science component of the curriculum because "biological science is medicine." Students should spend more time in laboratories "where biological science is revealed in well-planned, well-executed experiments that require problem solving" [9]. Some also suggest that only a thorough understanding of basic science will enable the physician to apply the fruits of scientific advance to future medical practice [9, 10]. Further, a thoroughgoing approach to basic science is necessary to foster future medical researchers among current students. Less often voiced but also important is the conviction that basic science serves a necessary gatekeeping function. Failure rates on National Boards Part I, the NBME (National Board of Medical Examiners) test of basic science knowledge, are higher than those for the clinical Part II, suggesting to some that academic rigor is best upheld in the medical curriculum by the basic sciences.

Current disagreement over basic science continues a long tradition of discomfort among physicians and medical educators with this part of the medical curriculum. The continued urgency of the dispute is suggested by the attention it presently attracts from bodies such as the Robert Wood Johnson Foundation, which has funded a Commission on the Sciences in Medicine to address the problem.

Part of the frustration engendered by the controversy lies in the tendency of both sides to talk past one another, arguing from conflicting presumptions about the nature of science and medicine, of which each side seems only dimly aware. I will examine this controversy by exploring the historical roots of the present-day rationale for the basic sciences in the medical curriculum. In so doing I will try to illuminate some of the assumptions made by those on opposite sides in the present conflict by uncovering their continuity with assumptions made by those fighting similar battles in the past. I will go on to suggest that the modern justification for the basic sciences in the medical curriculum is seriously flawed, and that some of our current difficulties stem from the role we have long believed these subjects to play in medical thinking and practice. While what I have to say may have more force for some than for others of these subjects, I wish to consider all of the present-day basic sciences in the following analysis. In conclusion I will consider why physicians study science, or should do so, and thus come to the proper place of basic science in the curriculum.

Historical Overview; Intellectual Roots of the Current Curricular Model

The present model of medical education had its origins in the 1880s and 1890s when young American physicians returned from study of the new laboratory-based basic sciences in Germany and sought to model

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American medical schools on their experience abroad [11, 12]. In Germany they had not only learned the methods of laboratory science but had imbibed the German scientific culture, a heady dose for many accustomed to America's lesser enthusiasm for science.

Many of those who returned brought an almost religious ardor to their efforts to further the cause of laboratory science in America. Osler remarked on the German devotion to science:

> I should say that the characteristic which stands out in bold relief in German scientific life is the paramount importance of knowledge for its own sake. To know certain things thoroughly and to contribute to an increase in our knowledge of them seems to satisfy the ambition of many of the best minds. The presence in every medical center of a class of men devoted to scientific work gives a totally different aspect to professional aspirations . . . [13].

As those physicians who had studied in Germany returned to medical schools in this country, they gradually developed a vision of medical education transformed by the culture of the German laboratory. That vision took as its starting point the laboratory methods so productive in Germany and so inspiring to American visitors. The thinking behind experimental design and execution was held to be an ideal model of scientific inquiry; students could not do better than to learn to observe and reason in the laboratory. By the 1890s and 1900s, the research reformers had deduced from their experiences in the laboratory comprehensive recommendations for medical school organization and teaching.

The reform program owed much of its rhetorical appeal to the frequent use of laboratory work as a metaphor for clinical practice. The ideal physician behaved as if he were a laboratory scientist; he hypothesized, experimented, and observed results just as the lab worker did [14, 15]. "We are, in a word, original investigators," remarked N. S. Davis, Jr., "and each case of disease is an original problem to be solved" [16]. From this premise, the reformers concluded that the training necessary for good clinical practice was that of the scientific laboratory.

> The true physician is a research-worker every day of his life, in the study of every case that comes to his care, and the best possible preparation for his work is exactly the same preparation which is needed for the investigator, in the largest scientific meaning of that word [17].

While students could not be expected to perform original investigations themselves, their recreation of important experiments in the laboratory would teach them the scientific thinking that they would afterwards use in practice [14].

As students were to learn to think as laboratory scientists, it followed that only laboratory scientists would be competent to teach them. The research reformers had begun by obtaining places in medical schools in

the "fundamental branches" (basic sciences), where their presence was quickly accepted. Clinicians might question the relevance of Germanic laboratory training to clinical medicine, but it was widely accepted by the 1880s and 1890s that contemporary developments in the fundamental branches might be much better taught by those who had had such training.

As the research reformers' vision gained acceptance, basic science departments began assuming their present-day complexion. The new value placed upon laboratory research led naturally to the favoring of laboratory-trained people in hiring for the new basic science departments. Such departments naturally perceived their task as the furthering of knowledge in the basic science disciplines as transformed by laboratory methods. Academic interests and publications were developed in this direction, and the Germanic Ph.D. became the favored credential.

Such development did not at first imply a necessary movement away from the interests and imperatives of clinical medicine. Physicians who had obtained German training could envision a career of research in the basic science disciplines while continuing to do clinical work. William Townsend Porter, a pioneering physiologist at Harvard, is a case in point. When orphaned at the age of 17, Porter began the study of medicine at the St. Louis Medical College. He received his M.D. after three years of study, in 1885. Within two years he had decided to pursue professionally an interest in physiology. The faculty of the St. Louis Medical School was eager to bring its physiology teaching up to date and sent Porter to Philadelphia to study, having appointed him to be assistant professor of physiology upon his return [18].

As Porter worked in the laboratories of the University of Pennsylvania, he made plans for his return to St. Louis. The presumption had been that he would, like professors of physiology before him, teach while maintaining a private practice. While in Philadelphia he developed another ambition, for "the acquisition of a private laboratory, wherein I can carry on some original investigations." Porter outlined his plan in a letter to Gustav Baumgarten, his faculty mentor in St. Louis. The two major obstacles were money and time. After detailing plans to obtain the necessary apparatus cheaply, Porter turned to the question of time:

> If my laboratory is in my office building there would be time in plenty without interfering with business. I hope to secure a large sleeping room, and use it for a laboratory. A small single bed will not take up much room, and a good tight fume-closet will remove unhealthy vapors [19].

Thus Porter, who was to do path-breaking work in cardiac physiology, could at this stage of his career envision doing professional physiological research single-handedly in a sleeping room attached to his medical office during time snatched from clinical practice and teaching.

To be sure, Porter was naive; yet he had by this time been exposed to professional physiology and chemistry at the University of Pennsylvania and had some notion of what was necessary to do laboratory research. That he could conceive of doing meaningful work in such a setting is a measure of the vast change in the basic science disciplines in the past century.

A would-be Porter would today require vast investments in further education, laboratory support, and time before he or she could hope to begin important research in basic science. While the research reformers did not foresee such changes in the wherewithal necessary for basic science research, such an evolution of the basic science disciplines is very much a natural consequence of the German model introduced by the reformers. A self-consciously disinterested approach to knowledge conceived in disciplinary terms necessarily moved basic scientists away from the concerns of clinical medicine. Much of the early laboratory work of the 1880s and 1890s had obvious implications for medicine and public health, particularly in fields like microbiology. As these fields matured, scientists pursued the ever-receding frontiers of knowledge deeper into the levels underlying clinical phenomena, exploring regions where connections to actual medical work became more and more tenuous.

As their interests diverged from clinical medicine, the credentials and training of basic scientists naturally evolved away from medicine. Disciplinary identity for fields like physiology, microbiology, and biochemistry came to depend less and less on any putative medical connection. Because they were employed by medical schools, basic scientists taught there; but their interests had developed away from those of medical students. Basic science courses necessarily took on the character of college undergraduate courses. As the frontiers of the basic sciences had receded, the problems facing these disciplines at the cutting edge had moved beyond the comprehension of prospective or even fully trained physicians. Those teaching introductory courses sought to provide the mass of material that had to be assimilated before problems currently facing the discipline could be intelligently addressed. Naturally such courses required much rote memorization.

Conceptions Underlying the Current Model

The research reform model was developed by men inspired, intoxicated by their experience of German laboratory science. While it was very natural for them to seek to interpret the medical student's experience and the physician's practice in terms of laboratory science, the metaphor deserves a closer examination than it has usually been given. In pressing the similarity between research and practice, the reformers argued from two important underlying assumptions: that clinical practice was (or soon would be) adequately conceptualized in terms of basic science, such that the matter learned in basic science courses would be of immediate relevance to practice; and that the process of doing laboratory science was generalizable to that of clinical medicine, such that learning "the experimental method" in the laboratory would lead to skill in solving clinical problems.

The first assumption was certainly plausible to a generation awed by the discovery of causative agents for some of the most feared infectious diseases in history; it was buttressed by venerable claims for the fundamental branches such as that one had to understand the normal before one could grasp the abnormal, and by architectural metaphors according to which these subjects were the base upon which the superstructure of the clinical branches was built. Yet when pressed as they were by the research reformers, these claims implied a wholesale reductionism that on critical examination is revealed to be untenable.

To the claim that it is impossible to understand medicine without knowing physiology, or that one must study chemistry to understand biology, it may be replied that the order may just as easily be reversed: that one cannot claim to really know chemistry until one is familiar with the behavior of chemical constituents in biological systems—and that therefore one must study biology to understand chemistry [20]. An insistence on the priority of study of an underlying level before studying a given higher level of phenomena is legitimate only if the higher level has been adequately and comprehensively conceptualized in terms of the lower.

Yet this reductionist presumption will not bear scrutiny. As has often been pointed out [21], the conceptions and phenomena of clinical medicine will not bear comprehensive reduction to the underlying level of basic science. Nor is there any prospect of such reduction succeeding in any assignable time to come. In the future as now, light may sometimes be shed on the higher level of clinical medicine by appealing to the lower level of basic science, and sometimes not. Clinical phenomena must be apprehended on their own terms instead of, or in addition to, those of basic science.

The relation between the basic science disciplines and clinical medicine suggests that what is wanted is not the study of basic science as conceptually prior to the study of medicine; clinical medicine should instead be studied on its own terms with digressions to basic science when the latter proves illuminating to the aspect of medicine in question. Basic science should be part of the medical curriculum when it is helpful for comprehending what physicians do.

What of the presumption that "the experimental method" of labora-