lakes or other fresh-water habitats located in a part, or parts, of a former continent (Atlantis).

We have thus three possible explanations for the presence of fresh-water diatoms in deep-sea sediments of the Atlantic:

Potamic theory. The diatoms originated in African lakes, swamps, and rivers; they were transported by rivers into the Atlantic and were drifted to, and deposited at, the present off-shore localities.

Aeolian theory. The diatoms originated in African lakes, rivers, and swamps. In dry seasons and after the desiccation of these swamps, rivulets, and so on, the fine dust of their bottom mud (often together with ashes of burnt plants) was taken up by the trade winds, blown into the sea ("Harmattan" dust), and finally deposited at the present localities.

Malaise's theory. The diatoms originated in a lake of the hypothetical continent Atlantis or of its remaining islands. The continent sank deep under the present sea level, and the geographic position of the locality of fresh-water diatoms remained unchanged.

All three explanations include a certain element of speculation; future investigations may decide which of them holds true.

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The Challenge to Dentistry

A Tribute to William J. Gies

Theodor Rosebury

William J. Gies, the founder of the International Association for Dental Research and of its *Journal,* died in his 85th year on 20 May 1956. It is my privilege to offer a tribute to his memory. Dr. Gies was primarily a medical educator and researcher. Among his many accomplishments before he became interested in dental problems was the distinction of founding, in 1898, the first department of biochemistry in a medical school. We are primarily interested in his achievements in the dental field—in education, research, and organization. These subjects claimed his energies increasingly during more than half of his long lifetime. Rather than attempt to catalog all he did, I propose to single out just one of his many works to symbolize his influence on dentistry. I am thus leaving biography and obituary to others (*1*). I intend to point out that dentistry, although it has made notable advances in the last few decades, remains short of the goals Gies set for it, particularly in the light of the inevitable comparison of dentistry with medicine. Dentistry, in my opinion, owes William Gies an incalculable debt of gratitude, which we can repay only by carrying forward the work he started. This suggestion is the essence of my tribute.

Bulletin Number Nineteen

It is of his famous *Bulletin Number Nineteen* (*2*) that I wish to write: the survey of dental education in the United States and Canada that Gies made for the Carnegie Foundation for the Advancement of Teaching. Published in 1926, the volume came to my notice a year later—just 30 years ago—while I was a dental student. A fellow-student and I read and studied it with intense interest. We found it then, as I find it now, a monument to the courage, the vision, the learning, and the literary grace of its author. It is incidental that, through my interest in the *Bulletin,* I came to know Gies, to win the Fellowship in Biological Chemistry in his name at Columbia University, and thus to derive from him the personal guidance and inspiration that led me into a career in dental research and teaching.

Since he died I have reread the *Bulletin.* I am struck with its persistent validity and vitality after three decades, and particularly with the light it throws both on our progress in dental education since he wrote it and on our deficiencies, which still remain to be corrected.

I select a few representative details. In the concluding part of the introduction to the *Bulletin* Gies speaks of the primary educational needs of dentistry as he saw them at the time. He asked, for example, for 2 years of college as a predental requirement; for the development of graduate instruction; for better cooperation between dentistry and medicine; for more complete dental libraries; for expansion of dental research; and for the disappearance of independent or proprietary dental schools. He emphasized the need for increased financial support for dental education and called for greater appreciation by dental teachers of the biological and medical side of dentistry. In a later section of the *Bulletin* he suggested that dental disease was being treated too mechanically and empirically because of lack of fundamental knowledge in the field, and that the means for prevention of dental disease were largely lacking, for the same reason.

The author is professor of bacteriology at the School of Dentistry, Washington University, St. Louis, Mo. This article is based on an address that he presented at the 35th General Meeting of the International Association for Dental Research, Atlantic City, N.J., 21 Mar. 1957.

He considered that many dentists at that time practiced superficially, even unprofessionally; that they regarded dentistry as a trade and a business rather than as a profession; and that, for this reason, medicine and dentistry had failed to reach the accord and cooperation required for the highest development of oral health service.

All of us who are old enough to remember the period of the *Bulletin* will be aware of the great progress we have made in these 30 years. Some of Gies' recommendations—a 2-year predental requirement, improved libraries, the disappearance of proprietary schools—have become accomplished facts. In all the other areas there have been advances—notably in research. Yet, though we take pride in our accomplishments, many of us feel, with concern, that some of the deficiencies Gies observed have not been obliterated. We have not reached our goals in medical-dental cooperation, in the development of research-mindedness among dental teachers as a group, and in the need for improved financing of dental education. We are much more biologically and medically minded in dentistry today than we were when I was a dental student, but we remain excessively mechanical in our approach to dental disease.

Dentistry, Medicine, and Science

In many parts of his study Gies compared dentistry with medicine. He had to do so. He needed a measuring rod, and medicine was the most convenient one. I intend to continue the comparison; but let me suggest beforehand that it is not entirely appropriate or fair.

Medicine is a much larger field than dentistry. When we use it as our standard we tend to emphasize its strength, which is the strength of the best of it, and to overlook the weakness that is certainly not lacking in it. The dental profession would not suffer if we could compare it with selected specialties of medicine more equivalent to it in scope. But medical specialties are parts of medicine; they are taught in medical schools and practiced by M.D.'s. Hence, it is less inappropriate to compare dentistry with medicine as a whole than with, say, obstetrics, dermatology, or psychiatry. We cannot avoid comparing schools with schools, one profession with another; but in doing so we must bear in mind that a discount—a discount that we cannot measure precisely—must be applied to the result. Moreover, to compare the change in dentistry with that in medicine during 30 years implies a calculus that involves other unmeasurable variables. This interval has seen a major depression, the greatest war in history, and sweeping postwar changes in human attitudes, objectives, and values. The passage of time has altered all of us, including the observer in this instance—myself. For these reasons I approach the comparison with humility; but it needs to be attempted if we are to judge William Gies' accomplishments.

It seems to me, to put the matter bluntly before I expand on it, that the great strides dental schools have made have been more than matched by even greater strides made by medical schools, so that the gap between dentistry and medicine has grown wider rather than narrower. We seem to be in a position somewhat like that of the Red Queen, who said to Alice, "Now, *here,* you see, it takes all the running *you* can do, to keep in the same place. If you want to get somewhere else, you must run at least twice as fast." We have run fast, but the world of medicine, from which we estimate our position, has moved ahead so much faster that we seem almost to have gone backward. This looks true to me in curious defiance of the fact that the advances in dental schools have occurred precisely in the areas where Gies found them most needed—in improved predental education, in research facilities and personnel, in research itself, and in the growth of full-time faculties, including a far greater proportion than formerly of research-minded teachers. Hence, if what I say is true, we must look to other areas for the reasons for it.

During an interval roughly equivalent to a single long lifetime—the lifetime, in fact, of William J. Gies—and particularly during his last 30 years, medical schools, and indeed the whole of medical practice, have undergone a transformation under the direct influence of experimental science. What seems to me most significant in this transformation is *the idea that disease can be understood and, if understood, controlled.* During this period many diseases have been ameliorated, others have been brought under a large measure of control, and an occasional one has actually been abolished locally—like cholera in the United States. Underlying these developments, the idea that disease is understandable and controllable has come gradually to be accepted, often tacitly, but nevertheless virtually universally. During the modern period this idea has become a foundation for nearly all medical research. As a direct result, medical men—not only researchers but clinicians themselves, in and out of the schools—have become convinced of the importance of science. Science as an attitude and as a method of learning has permeated every branch of medicine, and it is more in consequence of this event than of any other that medical education has reached its present eminence.

I do not wish to suggest that medicine as a practice is any more scientific than dentistry. In a particular sense, in fact, I suggest that neither practice is scientific, and that neither practice would be better if it *were* scientific. The practitioner of either medicine or dentistry needs to understand science, but he does not need to be a scientist. Science is concerned with the acquisition of new knowledge. Practice, to the degree that it leans on science, is concerned with applications. The practitioner's attention is focused on the individual patient, and it is enough if he can see the patient as a whole human being rather than as an isolated organ, cell, or enzyme, a jig-saw puzzle of clinical and laboratory data, a pair of dentures on an elaborate articulator, or a set of drives, tensions, and anxieties impelled by a pair of gonads. Science bears on understanding of all these parts and of the whole man, and even on the idea that the whole man is greater than the sum of his parts. That these contributions of science are essential is a feature of the great transformation in medicine that Gies saw during his lifetime. It is in this sense that medicine has come to accept the spirit of science.

The fact seems to me unavoidable that no comparable transformation has as yet happened in dentistry. Experimental science has grown apace in dental schools. It is taught better than it used to be; it is practiced far more extensively; but, with some noteworthy exceptions, its spirit has not yet caught on among dental students, dental clinical teachers, or dental practitioners as it has among their counterparts in medicine. It is necessary to learn something about science to be a dentist, but it is still possible to forget nearly all of it and yet be a successful practitioner, or even, in some areas, a successful dental teacher.

Conquest of Dental Disease

One must dig deeper at this point for reasons for this state of affairs. I am sure there is more than one reason; but one that seems to me pivotal is the fact that dental research, particularly research in dental schools, despite its great development, has not yet solved any of the problems of dental disease and has indeed contributed little to the everyday practice of dentistry. Fluoridation, of course, is an outstanding exception—a great achievement of dentistry, and by dentistry, for public health. Yet it must be recognized that most of the research that gave us fluoridation did not come from dental schools but came rather from American and Canadian federal, state, and provincial dental public health services. Similarly, the important advances in other areas of dental practice—for instance in nutrition, in pharmacology, in

chemotherapy, in anesthesia, and in many branches of dental technology—have come to us as much, or more, from medical schools and from industrial and government laboratories as from dental schools. Let me emphasize one point: if I seem to be laying blame for our deficiencies on research in our schools I must accept my own share of such blame, since my principal interest from the beginning of my career has been in problems of dental disease. But blame is not my point. It is now abundantly clear that the problems of dental disease are not simple, and I think it can fairly be said that our failure to conquer any of them is no more blameworthy than is equivalent failure in many areas of medicine. But we cannot point, as medicine can, to conspicuous successes that offset our failures, and, as we are a separate profession, our professional development must depend on successful research in our own field.

If, then, we are to follow in the path mapped for us by Gies and achieve for dentistry a status fully equivalent to that of the best specialties of medicine, we ought to set as an avowed goal the conquest of dental disease. In order to do so we must work also for Gies' explicit objectives: for increased medical-dental cooperation, for deeper and wider appreciation of research among dental teachers, and for more money for dental education. I think we can do all these things. Let me digress a little before I suggest what I have in mind.

Experimentation in Dental Education

In a little book that appeared not long ago (*3*), another of my esteemed teachers, A. Leroy Johnson, offered a suggestion that I should like here to reinforce and elaborate upon briefly. He suggested that the Gies *Bulletin* did not have as great an effect on dental education as did the earlier Flexner report on medical education. Medicine, according to Johnson, was more ready for change at the time because it already had an experimental school at Johns Hopkins. Dentistry had nothing of this sort. Following the appearance of *Bulletin Number Nineteen,* and doubtless stimulated in part by it, several experimental schools arose in the dental area, among them the ones at Rochester and at Harvard. It seems to me noteworthy that the Rochester experiment won general esteem from the start whereas that at Harvard, although it finally came to be accepted, was first received, as Johnson points out, in a spirit of controversy and even of hostility. A large part of this difference in the reception of these two projects seems to have depended on the fact that Rochester was never a dental school at all in the usual sense, while Harvard was such, albeit of a new sort. Harvard therefore seems to have been a challenge to intrenched notions, whereas Rochester was not.

This is not the place to offer a justification of the Harvard experiment *per se*. What I do wish to justify is the general principle of experimentation in dental education. It seems to me essential for the advancement of dentistry that we encourage more and more research, not only on particular problems of dental health and disease but in the broad area of dental education itself. The time is ripe for such experimentation. The need for more dental schools is clear and is slowly being met (*4*). I suggest that some of these new ones should be (and even that some of our old ones should become) frankly experimental, and that they should be encouraged and supported as frank experiments. It must be remembered that here, as elsewhere, experimentation is uncertain in outcome; a proportion of failure must be allowed. As Claude Bernard (*5*) put it, "We are all likely to make mistakes, except those of us who do nothing." The same idea is expressed by van Niel (*6*), who, considering the apparent wastefulness of mutation as an evolutionary mechanism, suggests "that the development of something new, even in human endeavor, is generally the outcome of efforts many of which yield only negative results."

And so I wish to suggest that at least two things be done to forward the status of dentistry, consistently with the objectives set down by William Gies. The first is to broaden our horizon as experimenters to include dental education itself: to develop new schools, and to change old ones, in order to improve medical-dental cooperation and to encourage a spread of the spirit of science into all parts of the school. Let us look ahead to the time when the practice of dentistry will have become infused with the spirit of science and begin now to build schools accordingly. Together with such undertakings, better financing must be achieved, and with this sort of purpose I think it can be.

As part of such efforts I suggest, in addition, that an attempt be made to apply a dearly learned lesson of the late war. Side by side with individual research, in which the qualified investigator is left free to roam as he pleases, there is a place for the cooperative or group approach. Here a number of partners drawn from different disciplines work together to solve a particular problem. This teamwork approach was highly developed by the British in the early years of the war in the application of science to the study of military operations. It has since come to be used widely in industry and in many areas of medicine in the effort to solve problems of both basic and applied science. Dentistry has not taken full advantage of its potentialities. Such a group works best with only nominal leadership, as a string quartet plays under the subtle guidance of the first violin. I can testify from personal wartime experience not only that this cooperative method is effective but that it can be an exhilarating experience for the individual researcher. It might be a way of getting at the roots of our problems of dental disease.

To do these things will require vision, courage, imagination — qualities that stand forth in the William J. Gies of *Bulletin Number Nineteen.* I do not suggest that my ideas about how they might be done are the only feasible ones but only that the job needs doing, and that the doing of it would embody the noblest tribute we could offer to Gies' memory. Let us try to move closer to the goal he set for himself and for all of us.

References and Notes

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