REMEMBRANCE OF THINGS PAST
AND CONCERNS FOR THE FUTURE

Stanley G. Schultz received the seventh annual Arthur C. Guyton Physiology Teacher of the Year Award. The following is a speech delivered as he was presented the award at Experimental Biology '99 in Washington, DC, in April 1999.

At the outset I would like to express my gratitude to those who nominated me for this high honor, to the Teaching Section of the American Physiological Society, who selected me from what I am sure was a field of equally deserving candidates, to the W. B. Saunders Company for their generous support of this award, and last, but by no means least, to Arthur Guyton, whose leadership within the ranks of teachers of physiology can be challenged by none.

While I had known of Arthur Guyton by name and reputation since the early 1960s, I first met him a quarter of a century ago—it is strange that for some reason “a quarter of a century” seems longer and more impressive than 25 years. In any event, it was at an editors meeting, in 1974, when Guyton was the 47th president of the American Physiological Society and I was editor of the Gastrointestinal Section of the American Journal of Physiology. The hot topic of debate, at that time, was whether or not to accept the recommendation of the Publications Committee, chaired by my dear friend, the late Peter Curran, that the AJP be published in sections, as it is now, and what impact this might have on the integrative nature of physiology; I will come back to this subject later. I have always held Guyton in the highest regard for becoming one of the giants in physiological research and education, for his leadership in the education of the public regarding the humane use of animals in biomedical research, and for setting uncompromising standards of academic excellence for all of us to emulate.

What I plan to do in this short communication is to share some impressions gained during my odyssey of almost one-half a century as a student and teacher of physiology and speculate a bit about the future of the teaching of physiology to undergraduate medical students. The opinions expressed in this paper are not the results of systematic surveys. They are, instead, impressions that I and some of my colleagues, who would probably prefer to remain “anonymous sources,” have gleaned over the years. In the speech that Barbara Horwitz gave when she received this award in 1996, she quoted from Mark Twain: “Predictions are very difficult to make, especially when they deal with the future.” I agree, but none the less, I will give it a try.

My first exposure to physiology was during my freshman year as a medical student at the New York University College of Medicine almost 50 years ago. The department at that time was chaired by the legendary Homer Smith, who was the quintessential “physiologist-philosopher,” inspiring students with as much of the latter as the former. This was in 1952, when Hodgkin and Huxley published their series of five papers that was to win them the Nobel Prize—but the theory was too fresh to have worked its way into the standard medical school texts. The secret of life was also still a secret since the Watson and Crick paper on the structure of DNA was not to appear until 1953.

That was the time when you could close your eyes and tell what department you were in by its odor: animal excreta and shellac from the kymograph prep room for physiology, organic solvents for biochemistry, formaldehyde for anatomy, and so on.

Those were the days when students wore ties!

Perhaps more to the point of this communication, as I have attempted to convey in Fig. 1, is that at that time there was a reasonably close coincidence between the material covered in our first-year course in mammalian
physiology, clinical physiology—that is to say, physiology immediately relevant to the bedside—and the research interests of our faculty, their graduate students, and their postdoctoral fellows. Parenthetically, I should note that the degree of overlap of the circles in Fig. 1 is meant to be illustrative of my argument rather than quantitative.

Medical students could walk into the laboratory of any faculty member and appreciate the research projects being pursued. Indeed, the medical school course in physiology was almost comprehensive enough to serve as a general course for graduate students.

Our “small group activities” were traditional “blood-and-guts” laboratory exercises that were scheduled for 3-4 hours per week throughout the 22-week course. They were supervised by the members of the faculty and, often, their graduate students and postdoctoral fellows, all of whom were familiar with, if not expert in, the various areas of medical physiology covered in the course. All of the faculty perused the, then, single volume of the *American Journal of Physiology* or at least scanned the table of contents. Most textbooks of medical physiology were single authored.

Most of the graduate students and postdoctoral fellows were destined for careers in academe and were equipped to discharge teaching assignments to undergraduate medical students in virtually any area of medical physiology.

In short, in those days, medical physiology was a single discipline. The educational program for first-year medical students was the fabric that consolidated and identified the department.

My how things have changed!

For one thing, students have substituted baseball caps (often with visors turned backwards) for ties.

Even more important, during the past 50 years there has been an explosion of knowledge in the physiological, and closely related biomedical, sciences—largely in a reductionist direction—that has far outstripped the content of most first-year undergraduate courses in medical physiology and the requirements for the practice of clinical medicine (Fig. 2).

First-year medical students must still be taught about Starling’s laws of the heart and the capillary, about glomerular filtration and renal clearances, about tidal volume and residual lung capacities, and so on. This is the language of clinical medicine—and will always be so. However, these subjects are certainly not the stuff that make for active research programs, competitive grant applications, and faculty promotions.

Consequently, the first-year course in physiology is by no means suitable for today’s graduate students. Further, for a variety of reasons, including cost, student resistance, and, not the least, a shortage of competent faculty supervisors, intensive whole animal laboratory experiences have been largely abandoned.

It follows that in the years that elapse between the completion of preliminary or comprehensive examina-
tions, where they still exist, and the completion of a postdoctoral experience, the future members of faculties of departments of physiology will have been far removed from, and, perhaps, will have little interest in, medical physiology.

In short, there is a distancing between what must be taught and the research interests and expertise of those whose responsibility it is to teach. Further, this tendency is not likely to change in the foreseeable future.

This problem is further compounded by the fact that the past 50 years have, not surprisingly, also witnessed an intensifying tendency toward subspecialization and subsubspecialization to the extent that physiology is no longer a single discipline.

It is not just that an individual has an intense research interest in a given subject—we all have that! It is that an individual, often, has no interest in any area that falls under the umbrella of physiology other than their research subject.

Subspecialty meetings are on the rise, whereas general meetings are threatened with extinction. General journals are succumbing to sectionalization and subsectionalization. Single-authored textbooks—like Arthur Guyton’s masterpieces—are things of the past.

Further, not only has the discipline of “medical physiology” become splintered, but many physiology departments have become increasingly focused on one, or at most two, of the splinters. There is no longer an attempt to “cover the waterfront” and have each major subsection represented on the faculty. Years ago, I recall seeing advertisements for an individual to fill a teaching vacancy in, say, pulmonary physiology who was also expected to establish an independent research program. Today, the ads that come across my desk, more often than not, are for individuals to strengthen a research program, a program project grant, a center, and so on, and they need not even have had training in physiology; teaching responsibilities very often go unmentioned.

To be sure, all of this is understandable, entirely justifiable, and in some instances, even laudable, but we should be aware of the consequences. I fear that this tendency will inevitably take a toll on the quality of undergraduate medical education in physiology. There is little hard evidence that this is happening now—probably because there still are enough senior faculty who received their education in more traditional settings—but in years to come we dinosaurs will have become extinct and I am concerned that medical education in physiology will suffer.

Thus, in response to the question “Are we adequately preparing the next generation of faculty members of departments of physiology to teach undergraduate medical physiology?” my answer is, in general, an emphatic NO.

Now, this problem is certainly not unique to physiology. All of the basic sciences are experiencing a distancing between their research frontiers and the course material appropriate for first-year medical students—gross and microscopic anatomy being a prime example. How are these problems being coped with?

Many departments simply employ a cadre of trained individuals solely for the purpose of teaching that subject. These individuals are not expected to establish independent research programs, are often on a nontenured track, and, generally, are not well assimilated within the department. They are often perceived of, and view themselves, as “second cousins,” and this certainly does not lead to intradepartmental harmony. This approach also tends to propagate the wrong message regarding the priority of teaching in the medical school. I, personally, find this approach most distasteful.

Another approach is based on the belief that any individual with a modicum of gray matter between his or her ears—given time—can learn any material sufficiently well to lecture to medical students. This may be true if one feels that the only purpose of a lecture is, simply, to convey information. I feel that this is not the case, and, indeed, there are many studies that indicate that this teaching venue is not at all well suited for the purpose of simply conveying information. Instead, a successful lecture should also convey inspiration or excitement, and this can only happen if the lecturer has some passion for the subject. Conscripting busy faculty members to discharge what they may view to be an onerous responsibility does
not make for passionate lecturing—instead, the only passion it may elicit is likely to be directed at the departmental chair or course director. Further, this approach leads to a cohort of unidimensional teachers who would have difficulty conveying the seminal message of physiology, namely, the integrative nature of this discipline—the interactions among organs that results in homeostasis. This, after all, is the essence of physiology that distinguishes it from the other biomedical sciences.

A third alternative is to turn to members of clinical departments, which, in the case of physiology, are most usually members of divisions in departments of medicine who could complement members in departments of physiology in developing and presenting the course. If we want the first-year course to remain relevant to clinical physiology, why not have expert clinicians who are also excellent educators present it? A major, but not the sole, shortcoming of this approach is, of course, that it is prohibitively expensive in terms of human resources. Managed care has placed great demands upon a clinician’s time so that securing significant, regularly scheduled segments of protected time for first-year educational purposes seems difficult and unreasonable. Another serious shortcoming is that such an approach could erode the fabric that is the raison d’etre for the very existence of physiology departments.

However, there is another possible solution to this problem that, as yet, has not been adequately explored—but is lurking around the corner and will inevitably soon be upon us. This is the development of interactive web-based, computer-assisted courses in mammalian physiology and the other basic sciences and the establishment of “classrooms without walls” for the purposes of pre-clinical education. This is a potentially powerful teaching resource that has yet to be tapped in any systematic way, but it is coming as sure as night follows day and we should prepare ourselves for it. At my institution we have established the University of Texas-Houston-Electronic Press and I have agreed to serve as its chief editor. One of our goals is to develop multiauthored, multimedia courses in the undergraduate basic sciences that would be natural successors to multiauthored textbooks but would include the value-added features that only the electronic media can provide. Unlike textbooks, these programs would be interactive and would periodically examine a student’s acquisition of the material before permitting the student to proceed; thus the bright student does not become bored with the pace, whereas the slower student will not be outpaced by the presentation. They would also include audio, as well as textual, transmission and animated figures when appropriate; the dimension of time—an essential element in physiological processes—which cannot be represented in text, can readily be portrayed by animation.

Laboratory exercises so sorely missed in most of our physiology offerings can easily be replicated with one major loss of realism being the lack of odor—but given the rapidity with which the electronic media is advancing, I would not exclude the appearance of virtual odor in the future.

There of course would have to be flesh-and-blood “content experts” who would supplement this electronic classroom without walls, possibly drawn from the clinical departments. However, their jobs would not be to convey information—which hopefully would be accomplished electronically—but instead to clarify, integrate, and, in general, share their wisdom with the students—a much more gratifying role for an educator than lecturing to a large, amorphous class.

This approach would shift the focus from faculty-driven education to student-driven learning. As my dear friend Ernie Knobil keeps reminding me, it is what students learn and retain that counts, not what is taught.

An Internet-based program would, of course, have several advantages over computer-assisted programs on CD ROMs. First, it would be independent of the particular specifications or the operating platform of the computer; the only requirement would be a browser and access to the Internet. Second, hyper-texting would permit connections within the text to other programs at different sites, accessing references, and so on. Third, it could be readily and inexpensively modified, updated, and so on.

In summary, then, current trends suggest that to remain at the cutting edge of research and, thereby, highly competitive for increasingly important extramural funds, physiology departments will evolve into
highly focused research units and that graduate stu-
dents and postdoctoral fellows educated in those units
will be poorly prepared to educate undergraduate
medical students in clinical physiology.

Common research interests will replace undergradu-
ate medical educational programs as the fabric that
identifies and consolidates these departments.

I feel that the slack will be taken up by web-based
multimedia, multiauthored, computer-assisted pro-
grams supported, for the most part, by members of
the clinical faculty. Should this transpire, I cannot help
but be concerned over the identity and future of
physiology departments.

However, there is a ray of hope. I feel that a resur-
gence of “traditional,” “integrative” physiology is in
the offing, spurred by the extraordinary successes of
molecular genetics and, in particular, the human
genome project. During the past decade, we have had
remarkable success taking Humpty-Dumpty apart. As
a result, genes have emerged, and will continue to
emerge, with unknown, potentially complex, func-
tions in the body. A vast integrative effort will be
called for in the not too distant future directed at
putting Humpty-Dumpty back together again. This
task will befall the new field called “physiological
genomics,” and it will require the training of a new
generation of scientists who might truly be called
“integrative physiologists.” This new breed, which in
many respects will resemble the breed now becoming
extinct, will be capable of working hand in hand with
molecular geneticists in a truly daunting undertaking
that will make the sequencing of the human genome
seem like child’s play.

It is incumbent upon physiology departments to take
the lead in this inevitable development and not let this
opportunity slip out of our grasps. If we are success-
ful, this could narrow the gap between the expertise
of our faculties and clinical physiology and ensure our
continued, prominent role in undergraduate medical
education. If, on the other hand, we continue in our
current reductionist direction and relinquish this op-
portunity, I fear we will loose our identities.

In closing, let me simply say that I count the privilege
of being a teacher of aspiring physicians among the
blessings of my life, and I will be forever grateful for
the high honor that the American Physiological Soci-
ety has bestowed upon me.

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