Dr. Penny Hansen is an international physiology educator. She was born in America and became a Canadian citizen, and her husband is from Sweden. Dr. Hansen has a reputation throughout the world from international meetings and visiting professorships in North America and Europe. She received her bachelor’s and master’s degrees in Ohio, and her PhD and entire academic career have been at Memorial University in St. John’s, Newfoundland, which is closer to London than to New Orleans. She found a hospitable environment and stayed. Remember how some jet planes were grounded on Sept. 11 at Gander, Newfoundland; the local people opened their homes, transported passengers in school buses, and served them free meals for a couple of days.

Dr. Hansen has received local and national awards for her teaching skills. At St. John’s, her ideas about education quickly outgrew the Basic Science Division in the Faculty of Medicine. She went from Assistant Dean for Undergraduate Medical Education to Director of Academic Development for Medicine to director of a center for health professional education for five professional schools. With this track record she might have been chosen to be dean of a medical school.

Dr. Hansen’s most notable contribution to international physiology has been in editing our Society’s teaching journal, *Advances in Physiology Education*, for nine years. During that time, she has written provocative editorials, encouraged authors from developing countries, and found ways to incorporate fresh ideas about teaching. As far as I know, no other society in the Federation of American Societies for Experimental Biology has a journal devoted to teaching. This is a tribute to Dr. Hansen and her associate editors in their encouragement of teachers to do research on teaching and publish their findings.

Dr. Hansen will continue writing and is authoring a textbook entitled *Physiology of Life Situations*, which will have unique organization. Dr. Hansen was recently appointed co-chair of the Education Committee for the International Union of Physiological Sciences. In that role, she is responsible for conducting teaching workshops and providing resources to teachers of physiology worldwide, particularly in developing countries. She spends time each winter teaching at St. George’s Medical School in Granada. Dr. Hansen is also the elected chair of the Teaching Section for the next three years.

It is particularly appropriate that, on this Earth Day 2002, whose motto is “One People, One Earth, One Future,” we hear a citizen of Canada who teaches worldwide talk about...
"Physiology's Recondite Curriculum."—Roger TannerThies, PhD, Professor Emeritus of Physiology, The University of Oklahoma Health Sciences Center, Oklahoma City, Oklahoma.

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I’m going to start by telling you a little story—a true story.

Once upon a time, I traveled through Burgundy, in France, enjoying the good food and the extraordinary wines of its famous villages. One village, Saint-Julien-en-Beaujolais, held a special attraction for me, for there was the house in which Claude Bernard was born and raised and to which he returned for the last years of his life. The house is now a museum and contains the makeshift laboratory where he continued a lifetime of teaching and where he performed his final experiments.

As I stood there in the quietness of his small laboratory, a flood of feeling washed over me. I felt intensely proud to be a physiologist, to be part of the same scientific tradition as Claude Bernard. In fact, it is recorded that, on his deathbed, he referred to his students as his "scientific family" (Ref. 9, p. 250). My generation of physiologists are therefore his great grandchildren, and I am inordinately proud to be his scientific great-granddaughter.

As I stood there that spring day in his house, I imagined how it might be actually to have been Claude Bernard’s student—how exciting it would have been to join in discussions and experiments with him and his other students. One of his students wrote of “his sincere zeal for science, his absolute freedom from false pretension, his unsleeping spirit of curiosity . . .” Another student noted that he was “open-minded, and at the same time sure of himself . . .” A colleague said that, upon his death, his students lost a “guide and friend” (Ref. 9, p. 250f).

When reading Bernard’s own notebooks and lectures and what was written about him by his contemporaries and subsequently by historians, he takes shape in one’s mind as an extraordinary teacher and philosopher of physiology whose ideas are still entirely pertinent today, 150 years later. He created physiology as an experimental science and is justly famous for that. But he was also the first person to discern the centrality of physiology among its related sciences and to understand that it is physiology that lends meaning and significance to those other sciences. He ended a discussion on the place of physiology among other sciences by declaring: “But I repeat, in all of this it is life which is the object and the other sciences are only means of investigation. It is therefore necessary above all to be a physiologist.” (1)

Bernard’s students benefited from his profound understanding of the scope and importance of this emerging science. Nowadays some—but not all—graduate students of physiology benefit from the kind of good experience that his students must have had. I was fortunate that my mentor, K. B. Roberts, made sure that his graduate students understood and valued the broad context of physiology—its experimental roots, its relationship to other sciences and to society, its importance for understanding human health and diversity. During my years of teaching, I have come to think of these aspects of physiology as its recondite curriculum—aspects that are hidden from ordinary knowledge and understanding. To be sure, our graduate students are privy to this kind of broad and deep understanding of physiology. However, it forms a recondite curriculum for our other students, because we do not usually include these aspects when we teach undergraduate and medical and other health professional students. For these students, we provide a good education in the facts and concepts of physiology, but we have been remiss in not revealing to them other related important ideas and information.

In this lecture, I will describe three interrelated aspects of physiology’s recondite curriculum that our undergraduate, medical, and other students would
benefit from learning. I will propose strategies for helping students to gain this broader, more profound understanding of physiology.

In considering physiology’s recondite curriculum, I will ask you to view physiology first as a health science, second as a social science, and finally as an experimental science. I will focus somewhat on the situation in medical schools, although all of what I say has relevance for all undergraduate and health professional students.

PHYSIOLOGY AS A HEALTH SCIENCE

In medical education, there is tension between focusing on health promotion and disease prevention on the one hand and focusing on etiology, diagnosis, and therapy of disease on the other. Physiology, as it is being taught and learned today in most medical schools, is placed in the context of disease. Unfortunately, part of the reason for this is the emergence of problem-based and case-based learning as educational strategies. Make no mistake: these approaches have very much to recommend them, but the way they are being used in medical schools leads students to focus on pathophysiology and mechanisms of disease to the near exclusion of normal function. It seems as if we have retreated from defending the importance for medical students to understand physiology in relation to health and normal function.

How can this situation be repaired without sacrificing the many excellent educational benefits of learning in the context of clinical cases? One approach is to join with clinical colleagues in primary care to create cases in which patients have come to their physicians with health problems that require advice and education. I am referring to patient-doctor encounters in which the physician needs to understand normal human physiology in order to provide the best care for his patient and avoid unnecessarily medicalizing the patient’s problem (6).

Here is an example of how one of these cases might read.

A 35-year-old swing-shift worker comes to see his family physician. He complains of being unable to sleep and says that he’s been taking melatonin but it hasn’t helped. He’s been drinking up to ten cups of coffee a day in order to stay awake on the job, and recently he nearly caused an accident when he fell asleep driving home from work. He admits that he has been very irritable and that his wife has given him an ultimatum that he must see a doctor. He asks for scripts for sleeping pills and for “uppers” to help him stay awake.

Neither sleeping pills nor uppers nor melatonin is the answer for this patient. The doctor must understand the physiology of circadian rhythms, sleep, and alertness in order to explain to her patient, for example, why it is necessary to have a quiet, dark place for sleeping, why alcohol should be avoided, and why so much caffeine is counterproductive.

This case can trigger students’ learning about physiology topics such as generation of biological rhythms; pineal secretion and actions of melatonin; function, epidemiological characteristics, and biological significance of sleep; brain activity during sleep; and physiological effects of sleep deprivation.

Learning about the physiology of circadian rhythms and sleep using this case will provide the foundation for students to be able to counsel their future patients about the importance of sleep for good health and to discuss from a basis of evidence the use of melatonin, for example. Students will also be better prepared to manage their own sleep problems as they enter a profession that often requires long hours of work and being on call. And as always, learning about normal function provides the best foundation for learning about disease—here, the endogenous sleep illnesses.

Many cases can be created that portray similar situations, situations that are ideal for learning normal physiology and that have good validity because they comprise a substantial portion of primary care physicians’ encounters with patients. Here are a few more examples of this kind of scenario.

- A football player who is worried because he fainted during a summer practice; he has read about others who have died under similar circumstances
- A woman who has been gaining weight and asks for a script for diet pills
• a teenage boy who asks whether it is OK to eat creatine to help him “bulk up”

• a student couple who want to time a pregnancy so the birth will occur during a two-month summer break

I will now turn to the interrelated second aspect of physiology’s recondite curriculum.

**PHYSIOLOGY AS A SOCIAL SCIENCE**

Many topics in physiology are related to issues in public health, social welfare, ethics, and moral justice. We mostly do not use opportunities to discuss these with our students, even though bringing such discussions into our physiology curriculum would enrich it and make it more meaningful. Just as medical students will need to understand these issues to advise their future patients, individual students who learn about the social and ethical implications of physiology are better able to make decisions about their own everyday lives that are congruent with good health, safety, and social and moral responsibility.

Here are some suggestions for incorporating these aspects of the recondite curriculum into your physiology course.

When you are teaching GI physiology and use oral rehydration therapy as an example to illustrate intestinal transport mechanisms, you could take the few minutes required to talk about the use of ORT in developing countries in an effort to save the millions of infants and young children who die every year because their mothers are persuaded to use formula instead of breast feeding, because there is no clean water supply, because of the crushing poverty of the third world (8).

When you are teaching metabolism and endocrinology, you could talk about the frightening epidemic of obesity in the developed world—and its consequences for individual health and for national health care costs. Sixty-one percent of US adults are overweight or obese, and the cost of treating the resulting health problems now exceeds the cost due to the effects of smoking (10).

When you are teaching about circadian rhythms and sleep, you could consider with your students the enormous number of injuries and deaths that result from the actions of people with sleep deficits. About 100,000 traffic accidents are caused each year in the US by drowsy driving (4). The loss of just one hour of sleep when the clocks changed to daylight savings time resulted in an 8% increase in traffic accidents the following day in Canada (3).

Whether or not you have student labs using animals or human subjects, you could discuss the ethical issues that are causing so much public controversy today. Although it does not specifically address teaching about ethics, I refer you to an excellent essay by Ewald Weibel in a recent issue of *News in Physiological Sciences* (13). In it, he writes: “We must face it: the ethical dilemmas of the physiologist cannot be resolved. We must live with them.” I would add that we must ensure that all physiology students at all levels are made aware of the issues and are provided with reliable information about the use of animals and humans in research. Furthermore, we must model ethical behavior when our students are asked to serve as the subjects for laboratory exercises in our courses.

This leads me to the third aspect of the recondite curriculum.

**PHYSIOLOGY AS AN EXPERIMENTAL SCIENCE**

You are thinking that, surely, this can’t be part of physiology’s recondite curriculum. Surely, every student knows that physiology is an experimental science.

Now, I’ll tell you another little story—another true story. I was discussing a point with a second year medical student, and we were referring to his physiology textbook, open in front of us. I said something that made him stop, look up at me, and exclaim: “Do you mean to tell me that everything in this physiology textbook was discovered by doing research?”

I was shocked, and Claude Bernard was spinning in his grave.

This was a good, middle-of-the-road medical student, not at all obtuse. Yet the idea that physiology was an experimental science was obviously news to him. I
realized then that my colleagues and I had failed very badly—both to convey something essential about the nature of physiology and to lay the foundation for practicing medicine in an hypothesis-driven manner.

This was a turning point for me as a teacher of physiology. I had assumed that my students had at least a basic understanding of scientific research and had at least rudimentary skills in related areas such as quantitative representation of information. When I began to pay closer attention, I found that many of them did not. This student’s naïve question opened my eyes to this aspect of physiology that we often inadvertently keep hidden from our undergraduate and health professional students—the third aspect of physiology’s recondite curriculum.

What are the causes of this alarming state of affairs? Are students arriving in our courses with little background knowledge about the scientific method and quantitation? Certainly, with the trend in admitting students to medical school with diverse backgrounds, we cannot assume that they have strong preparation in science. Is the problem that they have had only “cookbook” laboratories—or perhaps no labs at all? Is it that historical notes describing the experimental origins of current physiology are absent from most textbooks and from our lectures? Is it that curricula are so crammed that they encourage memorization rather than deeper understanding and exploration of broader issues related to physiology? The causes are multiple and synergistic.

There are encouraging signs. A few authors have begun to weave historical notes into their textbooks, and the APS journal Advances in Physiology Education has published dozens of articles in the last decade describing inquiry-based student laboratories.

What are some things each of us can do in our classrooms, no matter how large our classes, how little curriculum time we have, or even how little control we have over our curriculum?

There is good potential for learning about physiology as an experimental science in the time-honored approach of students collecting physiological data using themselves as subjects. Significant value is added to this kind of lab if individual data are then collated and analyzed so that students can evaluate and interpret the class data. This may be the first and only time students have an opportunity to examine data they themselves have collected. First-hand experience with data collection puts students in an ideal position to think, for example, about sources of technical and human error. It has the added benefit of helping them to understand the range of diversity within a healthy population—to understand, for example, the difference between normal and average.

Given current restrictions on time and laboratory access, this kind of data collection and evaluation might be feasible only if done in a lecture hall. For example, students can measure their resting heart rates as they sit quietly. You can collect the data anonymously, analyze it, and present the results during a subsequent lecture. Class discussions or assignments can then be centered on critically appraising the results. You can show different ways to represent the data visually, explaining or asking why some are appropriate and others not.

This lecture hall-as-lab activity can be embellished by asking students to provide their self-identified level of fitness when they submit their heart rates. Then correlations can be discussed, providing a good launch for learning about control of heart rate and cardiac output and the nature of cardiovascular fitness.

Many other observations and experiments can be done with minimal or no laboratory resources. Students can collect and evaluate data on reflexes and reaction times, body composition, temperature regulation, special senses, and so on. There is an excellent source book, unfortunately out of print but currently being revised for mounting on an IUPS website. It is A Source Book of Practical Experiments in Physiology Requiring Minimal Equipment, prepared by the IUPS Commission on Teaching Physiology. Here you will find protocols for many student experiments, including a long list of ideas for inquiry-based labs to be designed by students.

BRINGING THE RECONDITE CURRICULUM TO LIGHT

Finally, I want to say something about the kind of intellectual work required to incorporate the recondite curriculum into our courses. It is scholarly work,
just as much as bench research is scholarly. Scholarship may be defined as the application of intellect in an informed, disciplined, and creative manner (5). In contemporary academia, it is expected that results of scholarly work will be peer reviewed and reported to colleagues by publication or at professional meetings. It is the creative element of scholarship—research findings and teaching innovations, embedded in a solid foundation of rationale and developed knowledge, that must be disseminated to advance science and education.

We, our institutions, our promotion and tenure committees, all recognize that planning research and evaluating its findings are scholarly activities. We are beginning to recognize that planning for teaching and evaluating the learning that results require an equally scholarly approach. It is encouraging that the Association of American Medical Colleges is currently engaged in a special project to define and promulgate the ideas and issues around teaching as a form of scholarship. I refer you to discussion papers in a special issue of AAMC’s journal Academic Medicine (5).

The similarity is remarkable between the scholarly activities required for good research and good teaching. Both require discipline in attaining and maintaining the currency, depth, and breadth of knowledge needed for formulating learning objectives or for formulating research questions. Both require creativity to develop a teaching and learning strategy or a research strategy. The results of both teaching and research must be evaluated, interpreted, and used to plan further teaching and research. Teaching innovations that result in better learning should be reported, just as new, important research findings should be.

APS and the Association of Chairs of Departments of Physiology (ACDP) have jointly developed and endorsed a useful list of learning objectives for medical physiology (2). The Human Anatomy and Physiology Society (HAPS) has created a list of objectives for undergraduate courses. Contact information is available at the societies’ websites (11). Both of them focus on the kind of knowledge objectives that we all agree are central to understanding normal function. A bioengineering educational consortium, known by its acronym VanTH, has taken a more comprehensive approach in developing their list of objectives, which they call core competencies (personal communication). These encompass knowledge, cognitive and communication skills, values, and attitudes. I have selected a few from their list of competencies to illustrate their relationship to what I have characterized in this lecture as the recondite curriculum.

**COMPETENCIES RELATED TO HEALTH AND SOCIETY**

Students should:

- identify and evaluate contextual information, including ethics, quality of life, and public health and safety
- understand global and societal impact
- be aware of contemporary issues
- show willingness to examine and adopt practices and ideas from perspectives very different from their own

**COMPETENCIES RELATED TO EXPERIMENTAL AND QUANTITATION SKILLS**

Students should:

- know and follow the scientific method
- make measurements and interpret data from living systems
- determine accuracy of computed results
- use tables and data graphics effectively
- use numbers to communicate technical ideas

Incorporating the recondite curriculum into physiology courses for undergraduate and health professional students would require not only that learning objectives similar to those of the bioengineers be defined but also that innovative teaching and learning activities be created to help students to achieve the objectives and that students’ achievement of them be assessed. APS, ACDP, and HAPS could help immeasurably by expanding their
knowledge-based objectives to include those currently in the recondite curriculum.

In closing, I return to our scientific great-grandfather, Claude Bernard. In a lecture at the Sorbonne, he made a prediction:

“. . .I am convinced that when physiology is far enough advanced, the poet, the philosopher, and the physiologist will all understand one another.” (Ref. 9, p. 130)

I believe that he was presciently referring to the advanced state of physiology that exists today, when we can and should reveal the poetic and philosophical and social implications of physiology’s recondite curriculum.

Thank you.

The ideas presented in this lecture originated and evolved through discussion and collaborative teaching with K. B. Roberts.

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