Charting a global future for education in physiology

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I START BY ACKNOWLEDGING Claude Bernard (1813–1878), for whom this lecture is named. Born in France, he studied medicine and became a major researcher and teacher. Among his major discoveries, from studying the pancreas and liver, he identified glycogen. He recognized and distinguished the sympathetic and parasympathetic nervous systems. In addition, he measured the effects of carbon monoxide and curare. His research and teaching led to a professorship in 1855, and he became a member of the Academie des Sciences in 1868. When he died in 1878, he was the first French scientist to be honored with a state funeral.

France in Bernard’s time was central in the development of physiology as a science; his teaching was highly regarded, and his writings were very influential. Indeed, they are still in print in an English translation (1). Named in his honor are a university (in Lyon, France), a museum, a school, and a hotel.

CONTESTS FOR TEACHING/LEARNING PHYSIOLOGY

Students learn physiology for a variety of reasons; programs and courses in physiology lead to a range of different outcomes. Physiology is a core subject for students who will become medical doctors, dentists, or practitioners in a range of health sciences. Others study the science from interest, with some of them hoping to undertake research, either in physiology or in a related area of study. Others learn physiology in the process of becoming veterinary scientists or to manage agriculture or aquaculture. Physiology, although not necessarily specifically identified as a subject, is also a core component of school and community programs on health or personal development. Not only will the content and the complexity differ, but it is clear that the needs of such different groups will only be met by using a variety of educational approaches.

The first step in designing a curriculum in physiology is therefore to identify the ultimate outcomes. Issues will include the level of knowledge and understanding, relevant practical skills, and problem solving in a context of physiology. The prior learning and experiences of the students will determine their needs: whether they are in primary or secondary school, enrolled in an undergraduate college or university degree, or training as graduates for a research or clinical career. The physiology they learn might be the major focus of their program or it may represent only one subject among many; it may be applied (e.g., in clinical programs), but it can be studied for its intrinsic interest. Local programs in physiology will also reflect national priorities and expectations as well as historical traditions. The resources and facilities available vary widely.

In institutions worldwide, local teaching practices and the type of curriculum have both been shaped by history. For example, former British or European colonies tend to retain undergraduate entry to professional programs, and physiology, as a single subject, can be the major component of a Bachelor of Science degree. In contrast, in North America, undergraduate degrees are often quite broad, and entry to medical and other health professional programs or research training is usually restricted to graduates.

NEW CONTEXTS AND CHALLENGES FOR TEACHING PHYSIOLOGY

When thinking about designing a course in physiology, the first challenge is to define the scope and extent of the discipline, that is, what is physiology? This issue can be illustrated by an update of a diagram previously published (Fig. 1) (12).

Physiology overlaps with many disciplines, and the boundaries between them are not rigid. We must now add genomics and proteomics to the original list of anatomy/histology, biochemistry, biophysics, cell biology, clinical medicine, neuroscience, and pharmacology. One obvious issue for teachers is to define reasonable limits and to avoid unnecessary duplication when subjects overlap. It is important to communicate with those teaching related disciplines, to clarify the boundaries and responsibilities, to agree on a consistent terminology, and to ensure that the approaches are consistent.

Within physiology itself, knowledge increases rapidly and inexorably. How can teachers and students cope with the increasing complexity of the content? Integrated programs that cross boundaries between disciplines are particularly difficult to design and manage. It is essential to set reasonable limits by defining what is to be learned and in what depth. Where possible, core principles can be identified, emphasized, and illustrated with some relevant examples. All the teachers involved must reach some agreement on the levels of skills the students should demonstrate; skills that students must use to recall information, apply it, or use it to solve problems or to stimulate further analysis and perhaps research. Furthermore, if we are to prepare our students for their future careers, we need to predict to some extent the likely future directions for the subject.
Increasingly, it is recognized that teachers must keep up with expanding knowledge not only in their specific discipline but also in educational practice. There is burgeoning literature relevant to teaching and learning, and now many universities and colleges offer some staff development in education. Some useful general books are listed below, in the References. New, valid, and effective approaches are appearing in the literature, for example, research-led teaching and best evidence medical education. High-quality, validated teaching resources are starting to become available (see, for example, the American Physiological Society’s website). Teachers find workshops and conferences to be valuable for enhancing teaching skills. The International Union of Physiological Sciences (IUPS) along with regional and national groups all contribute, working to support and expand existing international workshops. In addition, educational platform and poster sessions must be encouraged at national and international conferences.

Access to computers and the Internet is improving, but it is not yet universal. In any modern teaching program, we must help our students to locate, recognize, and evaluate the quality and utility of on-line learning resources. Many institutions now support flexible learning management systems to deliver parts of the curriculum. Using them, teachers can provide on-line access to learning materials, information about the program, interactive discussion forums, and on-line questions to encourage students’ self-assessment. Staff use information technology to locate up-to-date on-line content; they can also use it to access educational strategies and resources. There are examples of high-quality on-line or CD-based learning resources available; often they are best used in small groups (e.g., 3 students) who interact with each other to interpret and discuss. All resources, even those from reliable sources, must be rigorously evaluated for relevance, appropriateness, quality, and effectiveness. Increasingly, computers provide access to the literature, both in physiology and education. Librarians play a major role in identifying and evaluating on-line and text-based resources and then making them available as hard copies or on-line. Computers are used to record and store data in practical classes; they offer analytical tools for interpreting and presenting the results.

Evidence-based medicine, with its capacity to improve health care and reduce costs, is increasingly being supported in hospitals and universities. Medical students thus learn invaluable critical thinking and advanced computing skills (11) that can be applied to other aspects of their learning. Through resources provided for patient care, some medical schools may gain access to the Internet and the computers themselves, which can, of course, then be used in many different ways to support teaching and learning.

Physiology is an experimental science, but identifying and developing appropriate practical work for students is particularly challenging. Local and national ethical concerns determine reasonable limits to human and animal work. Good practicals provide opportunities for students to actively gain a range of generic and specific skills in planning and design, manual and technical skills (in preparation and mastering instrumentation), recording, analyzing, and reporting results. By working in groups, students gain experience in technical communication as well as in collaboration and teamwork. Costs often prohibit the use of technically sophisticated practicals relevant to modern developments in physiology. Nevertheless, students can be encouraged to work actively in groups, designing their own ways of testing hypotheses, even if the experiments themselves cannot be fully implemented. They can analyze data provided to them, e.g., from clinical measurements, if that is a key objective for the program. Students also learn valuable skills by collecting data themselves, analyzing their results, and presenting their findings orally, in posters or in reports. Again, group work is valuable and limits the use of expensive resources. It is usually better to provide a small number of high-quality laboratory experiences rather than to fill in timetabled hours every week with less effective and often repetitious activities.

Problem- or issues-based programs focus on learning across subject areas. Although integration can be initially confronting, physiologists have an obligation to contribute to the overall design of such programs: generating ideas, identifying and developing good topics and issues, and providing resources. The content must be mapped in some way to ensure that key issues and skills are included (5). Participation in integrated programs often involves venturing into new areas as well as collaborating across departmental boundaries. Staff will be called on to locate, adapt, or design validated resources and to contribute in different roles: as a tutor, lecturer, discussion leader, or practical class supervisor. They have a strong obligation to contribute to the preparation and marking of high-quality assessments, to supervise activities, to participate in reviewing the program, and to implement agreed changes.
Staff need appropriate development in new roles; it is an institutional responsibility (see Ref. 4). Some staff now seek opportunities to earn qualifications in teaching: certificates, diplomas, or degrees. Local teaching workshops or programs may be supported by a department, a faculty, or a central university teaching unit. Specific elements that participants are seeking include designing, implementing, and evaluating curricula; locating relevant, high-quality information (on both the content and the teaching process); applying modern information technology effectively; designing fair, valid, and reliable assessment; and planning and contributing to the evaluation of both individual units and the overall program. All teachers who contribute professionally to good educational outcomes must be appropriately recognized and rewarded.

ENHANCING TEACHING/LEARNING IN PHYSIOLOGY: SOME STRATEGIES

Designing an effective curriculum is a challenge, whether it is an entire degree program or one small unit within it. There are different levels of expectation: what a student might achieve in a single subject or a unit of study and what they should be able to do at the time of graduation. Whether such targets are called aims, goals, or outcomes, they need to be clear to all, realistic, and achievable. Teachers have an obligation to indicate broadly what the students should achieve by the end of the unit or program and to communicate those expectations to them (and to our colleagues in other departments or units). Staff need to feel some sense of ownership of those expectations through opportunities to participate in discussion as they are developed. An example of broad goals for a medical program (that of the University of Sydney) can be found at http://www.medfac.usyd.edu.au/futurestudent/med/index.php. These goals represent an enterprise that involved a whole faculty, the university, clinical staff in hospitals and in the community, patients, and community groups. Within an individual unit of study, a more restricted and specific set of expectations needs to be indicated, but they must be consistent with the overall aims.

It is useful to define generic skills or attributes that all graduates should achieve; such skills transfer across to other disciplines and programs. Many universities provide statements to guide both staff and students. An example is to be found at http://www.itl.usyd.edu.au/GraduateAttributes/statement.htm. More specific outcomes depend on the subject and the nature of the program; they might include the ability to understand and apply specific content, to communicate appropriately and solve problems in the discipline, and to demonstrate specific practical skills.

Students are readily confused by “mixed messages” that arise when the expectations are unclear or when teaching methods and assessment are not matched to stated goals. Consistency is important, whether in a single subject or in a whole degree program. “Constructive alignment” will ensure that the methods of delivery and assessment are consistent with stated goals (2). For example, a mismatch occurs if the aims are to encourage sophisticated...
problem solving but the assessment focuses on recall of isolated facts or if it is evident that significant parts of the curriculum are not assessed at all. Effective alignment requires teamwork and constructive collaboration.

The diagram shown in Fig. 2 offers a way of conceptualizing the elements of relevant issues prepared by staff, web-relevant image databases, short summaries of relevant issues that normally arise for discussion and study include the physiology and anatomy of the brain stem, fever and thermal regulation, neural infections, rural medicine, and hospitalization of children. Links are provided to a range of other resources, including the medical society website. For this problem, students justify the need) and a summary at the end of the week. Students have access to their previous “cases,” the library with a wealth of on-line resources, self-assessment tasks, and collaborative discussion. After the first tutorial, students (individually or in self-chosen study groups) can access relevant information they find. Another issue is that the students’ access to computers may be inequitable (some students have their own computers at home, whereas others have no such resources; some machines may be limited in bandwidth; some may be old and unable to cope with more modern programs), so staff may need to devise strategies to help those who are disadvantaged.

An example of an integrated on-line resource from the medical faculty at the University of Sydney is shown in Fig. 3 (see also Ref. 3). A visitor’s guide is available (see http://www.gmp.usyd.edu.au and follow the link to “product showcase”). The program is integrated and problem based (with 3 tutorial meetings/wk). The students start by seeing an image of the “patient” on-line. They hear a short statement about the presentation to trigger their group discussion. After the first tutorial, students (individually or in self-chosen study groups) can access relevant information provided by staff on-line in the form of short summaries, references, evidence-based medicine materials, and relevant images. Students have access on-line to timetables for classes, extensive library holdings available on-line, and a wide range of image banks and other learning resources. In addition, they can access

Fig. 3. The visual “trigger” for a problem in the second year of the University of Sydney medical program. The trigger encourages the students to observe and draw inferences; a short statement (heard as a “voiceover”) provides some limited information to start the discussion. The sidebar gives students access to their previous “cases,” the library with a wealth of on-line resources, self-assessment questions with feedback, and the students’ medical society website. For this problem, issues that normally arise for discussion and study include the physiology and anatomy of the brain stem, fever and thermal regulation, neural infections, rural medicine, and hospitalization of children. Links are provided to a range of other resources, including the timed release of diagnostic test results (as students justify the need) and a summary at the end of the week. Students have access to relevant image databases, short summaries of relevant issues prepared by staff, websites, journal articles, and evidence-based medicine resources.

Links to the Internet provide access for staff and students to a wealth of resources, but evaluating the quality of the information is an increasing challenge. Many colleges and universities support learning management systems (e.g., WebCT or Blackboard) to deliver aspects of programs: timetables, validated learning materials, quizzes, outlines and summaries, samples of examination questions, interactive forums, readings, formative assessment, and evaluation. Some courses are available in distance mode, entirely on-line. Staff need appropriate training and support to ensure that they make the best use of on-line techniques; quality control, reliability, and equity of access are important issues.

One key difficulty facing teachers is that the quality of on-line resources is variable. Both staff and students need help in learning to evaluate the validity and relevance of the information they find. Another issue is that the students’ access to computers may be inequitable (some students have their own computers at home, whereas others have no such resources; some machines may be limited in bandwidth; some may be old and unable to cope with more modern programs), so staff may need to devise strategies to help those who are disadvantaged.

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self-assessment (formative) questions at any time (the most-used part of the website, active at all hours of the day and night), on-line evaluation forms, their student medical society, and its bookshop. They use e-mail to contact staff and other students. Students can look backwards to all the materials they have already encountered, but they cannot access future problems. Staff have unrestricted access.

CONTEXTS FOR TEACHING/LEARNING PHYSIOLOGY: A GLOBAL PERSPECTIVE

Across the world, significant inequities still exist. Access to educational resources including libraries as well as technical equipment is varied. There is uneven capacity for staff to undertake research in physiology. Nevertheless, innovative educational methods are widespread. Information technology is becoming more widely available, but one challenge is to secure equity of access. Other significant issues include quality control, validation of materials, and the language used.

The IUPS Education Committee (formerly the Teaching Commission) has a long history of supporting those who teach physiology. There have been workshops associated with congresses in at Jenolan Caves, Australia, in 1983; Kuopio, Finland, in 1989; Inverness, Scotland, in 1993; Repino, Russia, in 1997 (14); Lincoln, New Zealand, in 2001 (13); and Pali Mountain, CA, in 2005 (6); and a workshop is planned for Japan in 2009. Physiology teaching workshops have also been held in association with regional groups, with the Federation of Asian and Oceanian Physiology Societies being the most active. IUPS has also supported workshops in India (1978) and Pakistan (1999) (15).

Into the future, IUPS plans to continue the tradition of international friendship and to support the robust networks that have developed. The Education Committee of 2005–2009 will include individuals drawn from across the world. They will be encouraged to engage with their local and regional groups to support teaching workshops and the inclusion of an educational section into local scientific meetings. National, regional, and international workshops will continue to emphasise the application of valid educational principles and strategies to the teaching of physiology.

In addition, the Education Committee aims to provide access (on-line and on paper) to high-quality, reliable, validated teaching materials and guides to effective strategies. Although these resources will initially be prepared in English, we will encourage our membership to assist by translating into other major languages. Initial funding has been secured for the project from the United States National Science Foundation (through the efforts of Dee Silverthorn, Joel Michael, and Marsha Matyas), and we will seek additional funding to extend the work. We also hope to secure some additional funding for on-line resources that will support the development of teachers’ educational skills, based on needs expressed in previous IUPS workshops.

The Education Committee will also endeavor to ensure that educational symposia and poster sessions are included regularly on the programs of the International Congress.

We aim to find ways of expanding the range of our activities in collaboration with the education committees of related international groups: the International Brain Research Organization, the International Union of Biochemistry and Molecular Biology, and the International Union of Basic and Clinical Pharmacology.

Finally, I look forward to working with fellow physiologists across the world to enhance the learning experiences for students and the teaching skills of staff.

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REFERENCES