DESIGN AND EVALUATION OF A NATIONAL SET OF LEARNING OBJECTIVES: THE MEDICAL PHYSIOLOGY LEARNING OBJECTIVES PROJECT

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In 1998, the American Physiological Society (APS) and the Association of Chairs of Departments of Physiology (ACDP) began collaboration on a project to develop a set of physiology learning objectives for medical students. Over the next 2 years, more than 50 physiologists collaborated in the development a comprehensive draft containing its 695 learning objectives. Faculty in 31 medical schools in the United States, Canada, and Puerto Rico evaluated these objectives. On the basis of this evaluation, the ACDP recommended deleting 13 of them. The final project, containing 682 objectives, was approved in December 2000 by the ACDP and published on the APS website http://www.the-aps.org/education/MedPhysObj/medcor.htm. The identification of the “content” of medical physiology instruction provides the APS and the ACDP with a tool to introduce emerging topics, such as the physiology of aging and gender differences, at a national level. The medical physiology learning objectives project provides a guide for directing current and future medical physiology instruction in the United States.


Key words: teaching; assessment; exit standards

As medical and other professional schools in the health sciences continue to modify their curricula, a variety of approaches is being used to teach the students. These widely diversified approaches range from the traditional and systematic course in physiology and neuroscience to those in which there is not an identifiable course in physiology (1). Whereas a systematic presentation of physiological concepts under the direction of physiology faculty continues to be the most efficient way to ensure appropriate depth and breadth, physiologically related topics are often spread out over several courses. It is, nevertheless, essential that all medical and health professional students receive sufficient exposure to the physiological concepts that provide the foundations needed for further studies in pharmacology, pathology, pathophysiology, and medicine. The mechanisms of deranged function cannot be appreciated without an in-depth understanding of basic biophysical and physiological mechanisms.

One approach to insure adequate coverage of a topic is to establish explicit exit expectations. In the 1950s, Bloom (2) and Mager (5) popularized a pedagogical approach that relied heavily on learning objectives. By establishing explicit learning objectives, student mastery of a topic can be assessed and evaluated, independently of the instructional mode used.
In 1998, the president of the American Physiological Society (APS; L. Gabriel Navar), the president of the Association of Chairs of Departments of Physiology (ACDP; Mordecai P. Blaustein) and the chair of the APS Teaching Section (Robert G. Carroll) met to discuss ways in which to assist faculty who teach medical physiology. This group initiated a project that would develop a set of learning objectives for medical physiology instruction. The learning objectives were organized around nine physiology disciplines. For each discipline, an objective writing committee was recruited and cochaired by a member of the relevant APS section and a member of the ACDP. The APS teaching section coordinated the project, managed the time line, and provided a template and pedagogical support for constructing the objectives.

This paper describes the design and evaluation of the medical physiology learning objectives project. Key aspects in the design of the project include early involvement of the decision makers, soliciting broad input from content experts, providing opportunities for feedback and revision, and a broad-based evaluation. The result of this project is available on the APS web page at http://www.the-aps.org/education/MedPhysObj/medcor.htm.

**METHODS**

**Constructing the learning objectives.** Two groups within the physiology community were approached to provide leadership for this project, the APS Section Advisory Committee and the ACDP. The discipline of physiology was divided into nine sections: cell, cardiovascular, neurophysiology, endocrinology and metabolism, respiration, gastrointestinal, renal, muscle, and exercise and integration. An objective writing group was recruited for each of the areas, with the representative of the ACDP and the representative from the APS section serving as co-coordinators (see Table 1).

For each section, learning objectives were written and compiled over a period from December 1998 through February 1999. The co-coordinators compiled the objectives for the section and edited them for redundancy and format. A master list of the entire objectives project was compiled by April 1999 and again edited for redundancy and format. The compiled objectives were posted on the APS web page and presented at the 1999 Experimental Biology meeting. In June of 1999, the objectives were distributed to members of the ACDP, who were asked to relay them to interested faculty. In November of 1999, suggested revisions were distributed to the objective writing groups, and the revisions were finalized at the December 1999 ACDP meeting. The revised objectives were again posted on the APS web page.

The January 2000 draft had a total of 695 individual objectives. Of those, 48 objectives addressed cellular physiology, 128 objectives cardiovascular physiology, 144 objectives neurophysiology, 102 objectives endocrine physiology, 58 objectives pulmonary physiology, 86 objectives gastrointestinal physiology, 77 objectives renal and acid-base physiology, 39 objectives muscle physiology, and 15 objectives exercise and integration physiology.

**TABLE 1**

<table>
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<th>Project Coordinators</th>
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<td>R. G. Carroll, L. G. Navar, M. P. Blaustein</td>
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**Authoring Committee Membership**

**Cardiovascular** Coordinator: D. F. Peterson; Members: M. C. Andresen, A. E. Taylor, H. V. Sparks.

**Cell and General** Coordinator: M. P. Blaustein, Members: E. L. Boulaep, N. Escobales, R. B. Gunn, R. F. Rakowski, L. Reuss, S. G. Schultiz

**Central Nervous System, Neural Control and Autonomic Regulation** Coordinators: M. I. Phillips, R. H. Ray, R. D. Foreman


**Exercise and Environmental Physiology** Coordinators: D. Robertshaw, P. A. Gwirtz, C. M. Tipton

**Gastrointestinal** Coordinators: J. A. Williams, L. R. Johnson, Members: J. D. Wood, T. Smith


**Respiration** Coordinator: A. E. Taylor, M. I. Townsley; Members D. L. Beckman, J. C. Parker

**Muscle** Coordinator: J. A. Rall

In addition, numerous members of the ACDP worked on the objectives at the 1998 and 1999 ACDP annual meetings.
Evaluating the learning objectives. The January 2000 draft of the medical physiology learning objectives project was distributed to 150 medical schools in the United States, Puerto Rico, and Canada. Contact individuals were either members of the ACDP or, for those schools in which an ACDP member was not identified, through the individual responsible for curriculum/medical education as listed in the Association of American Medical Colleges (AAMC) guide.

In each school, appropriate faculty were asked to review the objectives and to rank them on five-point scale, with 5 = essential, 4 = important, 3 = appropriate, 2 = of questionable value, and 1 = inappropriate. Faculty were asked to consider the objectives only in light of the medical physiology instruction. Suggested reasons for rating an objective as inappropriate included: too detailed for medical students, not related to medical practice, or more appropriate for another basic science discipline such as pathology or anatomy. Scantron grading sheets, coded to identify the institution and the physiology topics, were included in each packet; faculty were asked to return the rating sheets by November 2000.

RESULTS

Responses were obtained from 31 different medical schools (20.7% response rate), and in some schools, multiple faculty evaluated each section. One exception was neurophysiology, where only 22 schools responded. This is likely because neurophysiology is not always a component of medical physiology courses. Responses were obtained both from schools using a lecture curriculum as well as schools using a problem-based curriculum.

For each section, average ranking of the objectives ranged from 3.6 for neurophysiology to 4.5 for endocrine physiology. All other sections had average rankings between 4.1 and 4.2. (Fig. 1).

Two different approaches for culling inappropriate objectives were considered, one based on absolute ranking and the other based on standard deviation. For absolute ranking, 13 objectives ranked below 3.0 (Fig. 2) and 65 objectives ranked below 3.25. With the use of standard deviation for each section, 21 objectives scored more than two standard deviations
below the mean for that section. In discussions at the December 2000 ACDP meeting, a cutoff point of 3.0 was chosen based on using the term “appropriate” as a 3.0 descriptor during the rating phase. A list of objectives deleted based on this criterion is included in the APPENDIX.

One objective deserves particular attention. Because of an editing mistake, objective cardiovascular 102 was shortened to “Explain the unfavorable,” with the rest of the sentence deleted. The average ranking for this objective was 1.56, with 2 individuals ranking it as essential, 2 as important, 2 as appropriate, 2 as of questionable value, 11 as inappropriate, and 9 evaluators omitted a score. Although unintentional, this response pattern indicates that the rankings are generally, but not completely, reliable.

**DISCUSSION**

The Medical Physiology Learning Objectives Project lasted over 2 yr and resulted in the construction and national endorsement of 682 individual physiology learning objectives. Over 60 faculty helped construct and revise the objectives, and 31 medical schools participated in the evaluation of the final draft (see Table 2).

A national set of learning objectives provides guidelines for the breadth and depth of knowledge in the physiological principles and concepts that are considered essential for further progress in understanding mechanisms of disease and body defenses. Regardless of the specific didactic or educational approach used by any given institution, that institution must develop mechanisms to assure that the students are being inculcated with these basic principles and concepts at an appropriate depth of understanding. The development of these learning objectives will allow all programs to determine whether their students are achieving at least this basic level of understanding.

Although not formalized, national expectations for mastery of physiology have already been set. The United States Medical Licensing Examination, as a single pathway for licensure to practice medicine, identifies the physiology that the item writers deem as appropriate. Textbook authors and publishers similarly identify the physiology content when writing and revising textbooks. Other basic science and clinical science disciplines identify the physiology that they feel is an important prerequisite for student mastery of their material.

**TABLE 2**

Departments participating in the evaluation process

- Dartmouth
- Midwestern University
- Wayne State
- Des Moines University
- LSU-Shreveport
- Univ. Nebraska
- UMDNJ-New Jersey Medical School
- UMDNJ-Robert Wood Johnson
- Vanderbilt
- Univ. Kansas
- Univ. Puerto Rico
- SUNY Buffalo
- Uniformed Services Univ. Health Sciences
- Univ. Massachusetts
- Emory
- Univ. Alabama-Birmingham
- North Texas Health Science Center
- Univ. South Florida
- Northeastern Ohio University
- Univ. Central del Caribe
- Mercer Univ.
- Indiana University-Indianapolis
- Medical College Wisconsin
- Brown University
- U. Minnesota-Duluth
- Ohio State
- University of Maryland
- University of South Alabama
- University of Arizona
- East Carolina Univ.
- Tulane Univ.
These expectations are more appropriately set by a national organization of physiologists. In doing so, the APS and the ACDP gain the opportunity to review and revise expectations, and provide input into the material that will be taught and tested under the guise of physiology. Structuring the learning expectations as objectives is a common approach to managing instruction (4). The Association of American Medical Colleges has initiated a Medical School Objectives Project: http://www.aamc.org/meded/msop/report1.htm.

Under the knowledge objectives (4), the guidelines indicate that “For its part, the medical school must ensure that before graduation, a student will have demonstrated, to the satisfaction of the faculty, the following:

1) knowledge of the normal structure and function of the body (as an intact organism) and of each of its major organ systems

2) knowledge of the molecular, biochemical, and cellular mechanisms that are important in maintaining the body’s homeostasis”

Completion of the medical physiology learning objectives project at this time will allow the APS and the ACDP to shape the expectations of the medical educators. It will also be important to reconcile these objectives with the expectations of other basic science and clinical science medical school courses.

The process of compiling the learning objectives was facilitated by the fact that many physiology departments had already adopted learning objectives in their courses. In 1978, APS published a translation of a set of learning objectives used at the Institute of Physiology, University of Aarhus, Denmark (6). The effort of these Danish physiologists underscores the importance of using the objectives as a “living document.” The translation into English was the fifth edition of the Aarhus physiology objectives, and Christain Olsen at Aarhus indicates that the objectives are now in their 14th edition (Christian Olsen, personal communication). For this project, the ACDP has agreed to manage a cycle for continuing revision and modification of the objectives.

The Human Anatomy and Physiology Society (HAPS) has also established a set of curriculum objectives for undergraduate instruction (3), available at http://www.hapsweb.org/corecurr.htm. These objectives include course guidelines as well as aspects of course prerequisites and structure in addition to the content expectations. Again, HAPS has in place the system for review and revision of these objectives.

By necessity, the objectives define the content to be taught. Not addressed in this project are issues related to the format in which this content should be presented. This will be dictated by factors and constraints (i.e., class size, number of faculty) unique to each institution. Nevertheless, all of the objectives can be attained using multiple teaching formats, and faculty need to determine the optimum teaching/learning format for their students.

The curricular objectives are focused primarily on normal body function. However, it is recognized that this material must be presented in a context that will prepare students for their roles as physicians. Accordingly, it is suggested that, wherever possible, clinical examples can and should be used to illustrate the underlying physiological principles.

FUTURE DIRECTIONS

One advantage in defining the content of medical physiology is that it becomes clear what is currently missing in physiology courses. At the 2000 ACPD meeting, participants noted the absence of objectives related to gender-specific health issues and also to physiological changes across the life span. For example, the physiology of development and aging is likely to become an important part of medical education in the very near future. These and other items can be introduced as recommended curriculum components by introducing objectives dealing with these topics.

The APS hopes to use the framework of these objectives to organize materials for inclusion in the archive of teaching resources. Linking the learning objective, identifying tools for accomplishing the
objective, and providing options for assessment of student learning will allow physiology instructors to implement an objective-driven approach in their teaching.

Additional information about the objectives is available at the APS web page, http://www.the-aps.org/education/MedPhysObj/medcor.htm or from the author.

APPENDIX

Deleted Learning Objectives

CE-33. Describe how mitochondria use the electrochemical gradient of protons generated by oxidative phosphorylation to translocate ions and metabolites.

CV-51. Describe the process of hemolysis and the recycling of hemoglobin components. Identify the role of calcium and oxidants in altering red blood cell membrane flexibility. Contrast extravascular and intravascular hemolysis.

CV-102. Explain the unfavorable

NEU-43. Contrast the effects of medial syndromes and lateral syndromes of the medulla and pons.

NEU-44. Diagram the source of the cerebral arterial blood supply and venous drainage, including the Circle of Willis.

NEU-102. Describe the differences in cytoarchitecture between sensory and motor cortex.

NEU-109. Describe the columnar organization of the sensory cortex.

NEU-111. Distinguish unimodal and multimodal association cortical areas.

NEU-125. Describe the changes in the sleep cycle across the life cycle.

NEU-143. Describe the abnormalities produced by sectioning the corpus callosum.

R-12. Describe the ultrastructure of the epithelial cells comprising the various segments of the nephron, including apical and basolateral specialization, orientation, surface area, height, and number of mitochondria.

R-13. Describe the techniques currently available for the localization of specific transport proteins to individual nephron segments, and to membrane domains of tubular epithelial cells, including micropuncture, and antibody approaches.

R-36. Describe the molecular biology of the following renal transporters and their predominant localization along the renal tubules:


B. ion and water channels (K⁺, ENaC, Cl⁻, Ca²⁺, aquaporins).

C. coupled transporters (Na⁺-glucose, Na⁺/H⁺ antiporter, Na⁺-K⁺-2Cl⁻ symporter, Na⁺ phosphate symporter, Na⁺-Cl⁻ symporter, Na⁺-HCO₃⁻ symporter, Cl⁻/HCO₃⁻ antiporter).

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References


