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A PERSONAL VIEW

Setting national guidelines for physiology undergraduate degree programs

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THERE ARE MANY THOUSANDS of undergraduate students in physiology degree programs around the world. These physiology undergraduate majors are being trained without a formalized consensus on what makes a student into a degree-certified, "card-carrying" Physiologist and best prepares them for their future careers. Minimal discussion has taken place regarding curricular guidelines for Bachelor of Science (BS) and Bachelor of Arts (BA) degree programs in the discipline until recently. Therefore, the goal of this article is multifold: *1*) to provide perspective to the companion article in the previous issue entitled "Physiology undergraduate degree requirements in the U.S." by VanRyn et al. (30); *2*) to make a case for setting consensus guidelines for undergraduate physiology programs; *3*) to provide a set of questions to initiate discussions about setting program guidelines; and *4*) to invite my colleagues to join in the process of improving undergraduate physiology programs.

As shown in the companion article (30), a range of curricular requirements is in use for existing BS programs. That being said, there are also many points of consensus that could be formalized into minimal curricular guidelines for physiology programs. The value of having such guidelines is more consistent training of students, better alignment to published core concepts of the discipline, improved clarity among employers and graduate programs about the training of physiology degree holders, and the establishment of a basic scaffolding for development of new programs. Perhaps more importantly, if existing programs agree to share best practices with each other to create national guidelines, all programs and students will benefit. If this process is overseen by a governing body dedicated to maintaining guidelines, tracking and disseminating current publications on best practices, and the like, it streamlines the process and takes the burden of each individual program director to stay current.

Many other life sciences disciplines have professional societies or other governing bodies that support undergraduate curriculum guidelines, ranging from general suggestions for programs to full accreditation. Depending on the discipline, there are a variety of topics listed in the guidelines including the following: suggested core concepts and learning objectives, recommendations for internships and research opportunities, best practices for career and academic advising, faculty-to-student ratios, number of laboratory course offerings, etc. Examples include American Society for Biochemistry and Molecular Biology (4), American Chemical Society (2), American Society for Microbiology (5), and the American Kinesiology Association (3). For physiology, the natural governing bodies for BS curricula are as follows: the grass roots consortium Physiology Majors Interest Group (P-MIG), the American Physiological Society (APS), the Association of Chairs of Departments of Physiology (ACDP), the Human Anatomy and Physiology Society (HAPS), and numerous individual faculty, all of which have already been having discussions about physiology undergraduate education. Each organization has been focusing on a different part of the same issue with a common goal of better understanding the state of undergraduate education in the discipline and how to improve it. There has been discussion about course objectives, core concepts, programmatic assessment tools, program accreditation/certification, programmatic learning objectives, inclusion of professional skills, use of end-competency exams for majors, and more.

It is important that informed, forward thinking is used to plan comprehensive undergraduate programs that contribute qualified students to the national science, technology, engineering, and mathematics (STEM) job market and growing health care sector and provide a pipeline of well-trained students to support the future of physiology as a discipline. Physiology faculty, chairs, and advisors have a responsibility to provide excellent and unique disciplinary training to undergraduates that serves them well postdegree. Undergraduate program guidelines should be heavily inclusive of disciplinary facts and core concepts, yet should also provide guidance on how to promote and assess meaningful student learning, guide the improvement of science practices and skills, support the training of professional competencies [i.e., "soft skills" (a.k.a., professional skills, transferrable skills, 21st century skills); for example, teamwork, communication, cultural competency, etc.], and provide excellent career advising. To do this well requires keeping pace with the growing literature in STEM education and career trends so that programs can be designed using evidence-based practices.

As we consider setting guidelines to best meet the needs of students, key questions to consider include the following: *1*) what does it mean to be a Physiologist; *2*) who are our students; *3*) what are the guiding principles for teaching and learning in STEM education, including professional skills development; *4*) what are employment trends for life science majors and what are the entrance requirements to graduate/professional schools; and *5*) how should our programs and student success be assessed?

1. What does it mean to be a Physiologist?

Defining, or redefining, what it means to be a Physiologist is an active discussion in the field (8, 15, 18–20). Focusing on

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undergraduate education, it is of the utmost importance to decide collectively what it means to be a degree holder in physiology. What knowledge, skills, and competencies are expected of a degree holder? What can an employer or graduate program expect from a newly minted degree holder in physiology? This last question is vital. A clear, formalized vision of what it means to hold a degree in physiology would help students, employers, and professional schools know what can be expected of a graduate. The discipline needs to be well defined, including how it is unique from other related life science undergraduate programs and what is distinctive to the thought process of a Physiologist. We as physiology educators should carefully consider how what is taught in our courses is differentiated from other related disciplines, such as general biology, molecular biology, biochemistry, genetics, etc. Fortunately, there are published core concepts and learning objectives in physiology (22, 23) that can serve as the base as programmatic guidelines are developed.

2. Who are our students?

To best serve our students, faculty need to know who the students are, what they want, and where they are going. In other words, why are students choosing this major above other related ones? This requires collecting data from current and past students to determine their needs and views on the degree. My group recently published survey data from undergraduate physiology majors at Michigan State University about their interests in studying molecular or integrative physiology (29). Sixty-seven percent of physiology majors prefer systems/integrative physiology, whereas 11% have a blended interest in integrative and cellular physiology. In total, ~80% of undergraduate students who choose to major in physiology have a preference for systems physiology. This is aligned with unpublished internal findings from Michigan State University and the University of Arizona, showing that that 86% and 90%, respectively, of majors at these institutions have aspirations for health-oriented careers. When presented with a smorgasbord of majors, such as genetics, molecular biology, biochemistry, neuroscience, and others, students who want to study the human body in both health and disease choose physiology. Another aspect of knowing who the students are is to better understand who is choosing physiology as a major. For example, what is the distribution of men to women in the programs, what is the minority student representation and success, how many international students are attracted to the major, what are the mean incoming statistics and demographics [e.g., freshman grade point average, incoming SAT (Scholastic Assessment Test) scores, etc.]?

3. What are the guiding principles for teaching and learning in STEM education, including professional skills development?

Guidelines and references about best practices for student learning and career development are important to include in formalized curriculum guidelines. First, it is important that program directors and faculty who teach in the programs be informed about current literature on STEM teaching and learning. Numerous groups have published guiding documents for improving STEM education (1), high-impact educational practices (21), best practices for student learning (14), and national guidelines for inquiry-based experimentation and course-based undergraduate research (7), to name a few. Second, employer surveys tell us that STEM graduates are not prepared for the job market, and that students need to work on generalizable, cross-cutting skills (13, 16, 25, 28). "Employability skills 2.0" (10) is one reference that would be useful as a framework for developing curricular standards that include soft skill development in students. That document speaks to the importance of development of professional skills development and provides a practical framework for how to achieve these goals. Also, each department should have a meaningful discussion to set concrete programmatic learning objectives that are used to help guide course objectives. A key part of setting national guidelines for physiology is to promote and maintain an up-to-date set of resources, such as those above, for physiology programs and encourage departments to use these in a demonstrable manner in their curriculum.

4. What are employment trends for life science majors and what are the entrance requirements to graduate/professional schools?

While, as noted above, upwards of 90% of majors have career aspirations in a health care profession, approximately one-half of students stop with a terminal BS degree (11). Two keys in helping students navigate the variety of career paths are having well-informed advisors and ample opportunities for career exploration embedded in the program. The programs should balance excellent preparation for professional school admissions with adequate advising and building of career skills for those who seek employment immediately after graduation. About 60% of students identify as premedicine, with others interested in a wide range of other allied health fields. It is important that the curriculum be flexible enough for pre-physician assistant, pre-physical therapy, preoptometry, predentistry, prepodiatry, and other students to meet differing prerequisites, while also completing the major in 4 yr. Given that physiology programs are filled with aspiring health care professionals, an effort should be made to keep current on MCAT (Medical College Admission Test) and GRE (Graduate Record Examinations) requirements, as well as guiding documents from the American Association of Medical Colleges (AAMC), Howard Hughes Medical Institute (HHMI), and other agencies for incoming medical students (6). For example, AAMC is stressing interpersonal competencies, critical thinking, and reasoning (17). These are the same skills that are being stressed in employer surveys. Finally, for the subset of students with a desire to pursue physiology research at the graduate level, adequate opportunities should exist for undergraduate research experiences, whether course based or laboratory based.

5. How should our programs and student success be assessed?

   a. Even in the absence of a formalized accreditation process for physiology degrees, there are many tools that can be used for evaluation of courses, faculty, and programs. A key general resource is from the Partnership for Undergraduate Life Sciences Education (PULSE), who authored vision and change rubrics (24). These rubrics are grounded in best practices for life science education and are invaluable tools for departmental self-assessment. For example, these rubrics guide internal or external

assessment of course learning objective and beyond. In terms of physiology core concepts, the most relevant tool is a programmatic end-competency exam developed at the University of Colorado Boulder called the Phys-MAPS project (27). It may also be appropriate for each institution to have an internal assessment specific to their university and departmental goals. It would be worth considering formalizing a network of programmatic external review among related programs. In this way, faculty from related programs could serve as objective external reviewers of programs to provide a needed outside perspective, as is regularly done with external review of departments.

b. Other metrics of program success include student surveys during and on completion of our program, as well as tracking several years postgraduation. Such surveys would depend on departmental goals, but may include questions on student attitudes about the major, perception of courses and faculty, satisfaction with courses and advising, and reflections on if the program met their specific career goals or helped prepare them for the next step. Programs would be best served to know if their graduates are competitive in professional and graduate admissions and effective in finding relevant employment. While it may be difficult to track students after graduation, especially several years later, it is worth considering how this can be done most effectively. Sharing of best practices on collecting data from students among peer programs as well as data sharing across institutions are laudable goals. As noted above, it is also important to assess student soft skills. There are some great examples of soft skills assessment from engineering undergraduate programs (12). Finally, there is a movement to incorporate and assess quantitative skills due to the recent guiding documents that stress the value of proficiency in these areas (1, 6, 17). This is especially true when it comes to reported deficiencies in student ability to link math and quantitative reasoning to life sciences concepts. There are numerous excellent guiding documents and assessments in this area including the BioSQuaRE (9) and QUBES hub projects (26).

Other General Considerations

I suggest that each existing program, and those being newly developed, have substantive conversations about a cohesive curriculum. This would start by establishing a formal set of programmatic goals, aligned with the mission of the college, which are publicly available. Once established, these program goals should be mapped onto specific courses in the major to determine which objectives for the program are met by a particular course. Aligned, desired learning outcomes of the program would be included on the syllabus for all classes to show students how each course fits into a cohesive curriculum. Having program learning objectives made available to majors would help students understand the course sequencing and requirements of their major. This also allows for faculty to know when a particular concept or skill is being taught by colleagues and helps student know what to expect.

Without overarching guidelines, coursework in programs is based on local faculty expertise without looking at broader goals. While this is convenient for the faculty to teach in their field of interest and it represents academic freedom to function independently, does this offer the best experience for students? Whereas diversity in faculty expertise is certainly enriching to our students and brings uniqueness to each program by offering the most up-to-date training from experts in a preferred field, faculty should also be aware that their teaching is part of a complete curricula. Moreover, it is not currently possible for professional schools and employers to know what to expect when interviewing a physiology major, because each program is different. Formalized learning goals would help to ensure that a physiology major is comparable from one institution to the next and would help strengthen the perceptions of the physiology major to graduate schools and employers.

Some remaining questions that could stimulate discussions around setting national guidelines are as follows: which programs identify as "physiology" even if know by other formal degree names (e.g., kinesiology, biology, etc.); how many credits in physiology-specific coursework are adequate in a major; should physiology laboratory courses be suggested as part of a BS degree; is combined anatomy and physiology sufficient, or is dedicated physiology coursework desired; is it desirable to include recommendations for programs to offer a required capstone experience, such as a research experience, service-based project, or an internship; should BS programs have a required course to promote career exploration; should guidelines be set for instructor-to-student ratios in laboratory and lecture courses; and are there specific topics/courses, aside from physiology, to which all majors should be exposed (e.g., anatomy, pathophysiology)?

The Proposal

National guidelines for physiology degree programs at the undergraduate level would include disciplinary core concepts and learning objectives, encouragement to use published pedagogical best practices, recommendations for teaching and assessing professional skills, best practices on career advising, and use of appropriate programmatic assessment. The guidelines would be formalized and regularly updated by P-MIG with input from HAPS, APS, and ACDP. This information would be publicly available and hosted on a public web space.

Current State

Work has already begun to reflect on and improve undergraduate physiology education, and I invite you to join the process. The current stakeholders are P-MIG, APS, ACDP, HAPS, Phys-MAPS project, numerous individual faculty, the students, and future employers. National guidelines for degree programs in physiology will bring together work from the stakeholders into one place and present a consensus vision of undergraduate programs. One important step is that P-MIG hosted the first meeting of physiology undergraduate programs in May 2017 and has planned the second meeting at the University of Arizona in June 2018.

Getting Involved

You are invited to attend the next P-MIG conference, join the P-MIG networking session at Experimental Biology, join the P-MIG listserv, provide input into the process of improving physiology undergraduate education, or help in other ways. I

hope you will be interested in joining in this process to improve undergraduate physiology education, increase the success of BS degree holders, and to strengthen our discipline.

DISCLOSURES

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AUTHOR CONTRIBUTIONS

E.A.W. drafted manuscript; edited and revised manuscript; approved final version of manuscript.

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