The development and implementation of a new medical biology major including physiology

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Green BE, Koster KL, Swanson DL. The development and implementation of a new medical biology major including physiology. Adv Physiol Educ 39: 67–75, 2015; doi:10.1152/advan.00010.2015.—In response to the Howard Hughes Medical Institute/Association of American Medical Colleges Scientific Foundations for Future Physicians (SFFP) report and a concern for better preparing undergraduates for future doctoral programs in the health professions, the deans of the College of Arts and Sciences and Division of Basic Biomedical Sciences of Sanford School of Medicine of the University of South Dakota formed an ad hoc Premedical Curriculum Review Committee with representatives from the science departments and medical school. The Committee began by reviewing the university’s suggested premedical curriculum and matching it to the proposed competencies from the SFFP to document duplications and deficiencies. The proposed changes in the Medical College Admission Test for 2015 were also evaluated. The Committee proposed a stronger premedical curriculum, with the development of some new courses, including an inquiry-based physiology course with team-based learning, to more fully address SFFP competencies. These analyses convinced the university that a new major would best help students achieve the competencies and prepare them for admission exams. Thus, a new Medical Biology major was proposed to the South Dakota Board of Regents and accepted for its initial offering in 2012. The new major has been broadly advertised to future students and is successful as a recruiting tool for the university. This article details the process of evaluating the curriculum and designing the new major, describes some of the difficulties in its implementation, and reviews outcomes from the new major to date.

competencies; MCAT 2015; preprofessional education

BEFORE THE DEVELOPMENT of the new Medical Biology major at the University of South Dakota (USD), most premedical students chose to major in chemistry, psychology, or biology (with a molecular biology and physiology specialization) and take the set of suggested courses commonly required for admission to medical school. However, in response to the Howard Hughes Medical Institute (HHMI)/Association of American Medical Colleges (AAMC) Scientific Foundations for Future Physicians (SFFP) report (3) and a timely concern for better preparing undergraduates for future doctoral programs in the health professions, the deans of the College of Arts and Sciences and Division of Basic Biomedical Sciences of Sanford School of Medicine (SSOM) of USD formed an ad hoc Premedical Curriculum Review Committee (henceforth referred to as the Committee) in March 2011.

The initial charge to the Committee was to review the current premedical curriculum (Table 1) and suggest changes to better fit the knowledge and skill development needs (i.e., competencies) identified by the SFFP report (3). This remained the charge of the Committee throughout the spring semester of 2011. The Committee submitted a progress report in June of 2011 documenting shortcomings (2) of the current premedical curriculum for meeting competencies in the SFFP report and suggesting a revised premedical curriculum to alleviate these shortcomings. During the summer of 2011, discussions among administrators and faculty in the College of Arts and Sciences and SSOM of USD led to a new charge to the Committee. The new charge was to develop a new interdisciplinary major to be housed in the College of Arts and Sciences (7) that would include the revised premedical curriculum and other courses and training necessary to meet the competencies identified in the SFFP report (3) as well as recommendations from the November 2011 AAMC-HHMI Behavioral and Social Science Foundations for Future Physicians report (1). The goal was to have the new major approved and implemented by the fall semester of 2012.

Several confounding issues needed to be addressed in the planning of a revised premedical curriculum and a new major at USD. First, state institutions in South Dakota are regulated by a Board of Regents that has fixed deadlines for proposals justifying the introduction of new majors. In addition, the Board of Regents mandated in 2011 that required credit hours for all baccalaureate degree programs needed to be reduced from 128 to 120 credit hours beginning with the 2012–2013 academic year. Consequently, all majors at the university needed to carefully examine credit hour requirements to fit within the 120 credit hour total for the overall degree program. Second, undergraduate students in the College of Arts and Sciences are required to complete both a major and a minor before graduation. Third, while the USD School of Medicine faculty members teach a large number of undergraduate students in service courses for mostly health professional students, there are no programs with undergraduate majors in the medical school, and the medical school faculty members do not officially advise undergraduate students. Fourth, USD recently changed its budgeting to a Responsibility Center Management (RCM) process by which individual schools and colleges receive income based on student enrollments in their courses and must pay for other services provided by the university (mostly traditional administrative support centers). Fifth, USD has a strong and excellent Honors Program with specific additional course requirements and generally has a large percentage of honors students who are premedical students. Finally, a name needed to be chosen for this new major that would clearly identify it as a unique major in the Board of Regents system and would highlight the collaboration between the College of Arts and Sciences and SSOM in its planning and implementation. This new major should take advantage of the
fact that some of its required courses would be offered by faculty members of the only medical school in South Dakota, which is housed on the main campus of USD.

The Committee was designed to have representatives from the science departments in the College of Arts and Sciences (one representative from chemistry, one representative from physics, and two representatives from biology) and from some of the faculty members teaching undergraduate courses in SSOM (one faculty member who teaches biochemistry and one faculty member who teaches physiology) and to be chaired by one of the biology faculty members who was also the former chair of the Department of Biology. In the invitation for appointment to the Committee, the deans stated the follows:

As you know, the College of Arts and Sciences and the School of Medicine have been discussing areas of common interest. One area is the development of a new premedical undergraduate curriculum. You have been nominated to be part of a Committee charged with assessing USD’s current premedical curriculum and recommending changes to the curriculum to provide the best premedical training for our students. We hope the Committee can make its final recommendation by December 1, 2011 for implementation in Fall, 2012.

METHODS

The two deans participated in the initial meeting of the Committee in March 2011 to explain its charge and to answer questions. The SFFP report was provided for discussion and as a reference (3), as well as a report of the approaches being taken by the committee performing the Fifth Comprehensive Review (MR5 committee) to revise the Medical College Admission Test (MCAT) for 2015 (5).

The charge that was given to the Committee was as follows:
1. Review USD’s present “premedical curriculum” relative to the recommendations of the AAMC-HHMI SFFP report. Identify strengths and weaknesses.
2. Recommend how USD can best take advantage of its unique resources to prepare future students for success in medical school. This could include changes to existing courses, new courses, new approaches to delivering course content, new approaches to organizing premedical coursework, and/or ways to communicate changes to interested students.
3. Recommend how to integrate the premedical curriculum with other campus initiatives to improve medical education.

After carefully studying the SFFP report focusing on the introductory, implementation, and “Entering Medical Student Expectations” sections, Committee members discussed what courses (and portions of courses) in the 2011 recommended premedical curriculum (Table 1) and Molecular Biology and Physiology specialization of the Biology major met each specific competency. The assignment was for Committee members to map 2011 courses from their disciplines to the list of competencies for entering medical students to identify gaps in coverage and overlap in course content (Table 2). The SFFP competencies are listed below and are shown in Table 2. This mapping would allow comparison of the 2011 suggested premedical curriculum at USD to identify its strengths and weaknesses in addressing the proposed competencies and to provide a foundation for recommending changes to the premedical curriculum to better meet the proposed competencies.

For the mapping assignment, the Committee collected and reviewed syllabi from all required and recommended courses listed in the premedical curriculum and the Molecular Biology and Physiology specialization of the Biology major to measure course content against SFFP competencies. The Committee also discussed in detail specific content and skill development provided by particular courses, with the intent of meeting SFFP competencies with minimal overlap in course content. An example of these latter discussions involved evaluation of the specific content in the Structure and Function of Biomolecules and Principles of Biochemistry courses. The content in these two courses was organized such that the Structure and Function of Biomolecules course provided the necessary background for the Principles of Biochemistry course, so that content at the beginning of the Principles of Biochemistry course would not have to include basic material relating to biomolecules and could focus more on metabolism and other topics relevant to premedical students.

SFFP competencies: The SFFP competencies were as follows:
E1. Apply quantitative reasoning and appropriate mathematics to describe or explain phenomena in the natural world.
E2. Demonstrate understanding of the process of scientific inquiry and explain how scientific knowledge is discovered and validated.
E3. Demonstrate knowledge and basic physical principles and their applications to the understanding of living systems.
E4. Demonstrate knowledge of basic principles of chemistry and some of their applications to the understanding of living systems.
E5. Demonstrate knowledge of how biomolecules contribute to structure and function of cells.
E6. Apply understanding of principles of how molecular and cell assemblies, organs, and organisms develop structure and carry out function.
E7. Explain how organisms sense and control their internal environment and how they respond to external change.
E8. Demonstrate an understanding of how the organizing principle of evolution by natural selection explains the diversity of life on earth.

The Committee faithfully submitted progress reports to the administrators at the ends of June and December 2011.

RESULTS

Based on the analysis of how the competencies mapped to the 2011 suggested premedical courses at USD, the following strengths and weaknesses of the existing premedical curriculum (compared with the recommendations of SFFP) were identified.

Strengths of the 2011 premedical curriculum. Strengths of the 2011 premedical curriculum were as follows:
Some team-based and inquiry-based activities in laboratory components of introductory courses in biology, chemistry, and physics.

Contributions to suggested curriculum come from biology, chemistry, physics, math, and the medical school, so breadth of content in the current curriculum is adequate, particularly with some additional upper-division courses for majors in the natural sciences added on to the suggested curriculum.

Weaknesses of the 2011 premedical curriculum. Weaknesses of the 2011 premedical curriculum were as follows:

- Relatively weak suggested physiology component (only 200-level PHGY courses).
- Relatively weak in cellular and molecular biology content (some in General Biology courses and some in Biochemistry and Developmental Biology courses, but no suggested courses devoted specifically to foundations of cellular and molecular biology).
- Few "team-based" activities in courses, especially in upper-division courses.
- Few "inquiry-based" activities in courses, especially in upper-division courses.
- Few interdisciplinary offerings, including little awareness of overlap in course content between courses both within and among disciplines.
- Little evolution content covered in suggested courses outside of small portions in the General Biology sequence and in the Genetics course.

Questions that arose from the analysis. In the process of discussing these attributes of the 2011 suggested premedical curriculum, the members of the Committee also addressed several other questions:

1. Do appropriate integrative and interdisciplinary science courses exist at USD to fit the goals?
2. If not, do these courses need to be developed and which departments should develop them?
3. Does USD need to include courses with a team participation component in the curriculum?
4. What courses in the premedical curriculum help to develop the skills and attitudes needed to perform in medical practice and meet or exceed the standards of the profession?
5. What courses in the premedical curriculum focus on the application of knowledge or problem solving?
6. Does the 2011 premedical curriculum at USD sufficiently develop the communication skills necessary for physicians?
7. Are interdisciplinary science communication courses needed in the curriculum?

Before designing a draft premedical curriculum for future discussions by university departments and administrators, the Committee members also closely considered how the courses in a recommended premedical curriculum should help prepare students for the four test sections of the new MCAT in 2015 (Table 3) (5):

1. Biological and Biochemical Foundations of Living Systems
2. Chemical and Physical Foundations of Biological Systems
3. Psychological, Social, and Biological Foundations of Behavior
4. Critical Analysis and Reasoning Skills

The end product of these analyses and activities was an outline of a draft premedical curriculum to prepare students for...
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Table 3. Mapping of proposed Medical Biology courses to sections of the Medical College Admission Test in 2015

<table>
<thead>
<tr>
<th>Biological and Biochemical Foundations of Living Systems and Chemical and Physical Foundations of Biological Systems</th>
<th>Arts and Science Courses</th>
<th>School of Medicine Courses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test biology, organic, inorganic chemistry, and physics</td>
<td>General Biology (2)</td>
<td>Principles of Biochemistry (1)</td>
</tr>
<tr>
<td>Test biochemistry concepts</td>
<td>Biomolecules (1), Cell Biology (1), and upper-level Physiology (1)</td>
<td>Advanced Human Physiology (1)</td>
</tr>
<tr>
<td>Test cellular/molecular biology topics</td>
<td>General Biology (2), Cell Biology (1), Histology (1), Developmental Biology (1), and Molecular Biology (1)</td>
<td>Advanced Human Physiology (1)</td>
</tr>
<tr>
<td>Target research methods and statistics concepts</td>
<td>General Biology (2), General Chemistry (2), Physics (2), Biostatistics (1), and Senior Seminar (1)</td>
<td>Advanced Human Physiology (1)</td>
</tr>
<tr>
<td>Demonstrate scientific inquiry and reasoning to solve problems</td>
<td>General Biology (2), General Chemistry (2), Physics (2), Biostatistics (1), Senior Seminar (1), and upper-level Physiology (1)</td>
<td></td>
</tr>
</tbody>
</table>

Psychological, Social, and Biological Foundations of Behavior

| Test concepts in psychology, sociology, and biology related to health                                      | General Psychology (1) and Sociology (1) |
| Target concepts taught in 1-semester psychology and sociology courses                                     | General Psychology (1) and Sociology (1) |
| Target biology concepts relating to mental processes and behavior                                        | General Biology (2) |
| Demonstrate scientific inquiry and reasoning to solve problems                                            | General Psychology (1) and Sociology (1) |

Critical Analysis and Reasoning Skills

| Test analysis and reasoning skills from reading and comprehension, evaluation, application, information    | Upper-level Physiology (1) and Biostatistics (1)             |
| Test analysis and reasoning skills from reading and comprehension, evaluation, application, information    | General education courses                                      |
| Test analysis and reasoning skills from reading and comprehension, evaluation, application, information    | Advanced Human Physiology (1) |
| Test analysis and reasoning skills from reading and comprehension, evaluation, application, information    | General education courses and Biomedical Ethics (1) |
| Test analysis and reasoning skills from reading and comprehension, evaluation, application, information    | General education courses |

upcoming changes to the MCAT and to medical school education practices. After the submission of the draft premedical curriculum, discussions among the deans and other administrators took place, which led to a change in the charge to the committee to develop the draft premedical curriculum into a new Medical Biology major. This new charge involved much back-and-forth discussion among the committee, deans, and other administrators to address the impacts of the various confounding issues relating to the development of the new Medical Biology major. In March 2012, a proposal was submitted to the South Dakota Board of Regents for an intent to plan a new BS degree in Medical Biology beginning in the fall of 2012. In addition, consensus among the natural science departments of the College of Arts and Sciences, University Honors Program, and Division of Basic Biomedical Sciences of SSOM required several important compromises to clarify which courses would be required and which courses would be electives. After much discussion and negotiation with the administration as well as suggestions from curriculum review committees within the College of Arts and Sciences and the broader university, the proposal for the new Medical Biology major with an interdisciplinary sciences minor was ready to submit to the South Dakota Board of Regents.

The proposal for the addition of the new Medical Biology major for the South Dakota Board of Regents system was submitted in March 2012, with a proposed launch in the fall semester of 2012, and included the following written justification:

The Howard Hughes Medical Institute (HHMI) and the Association of American Medical Colleges (AAMC) have recently issued a white paper, “Scientific Foundations for Future Physicians,” that identifies specific “competencies” in the sciences that students entering medical school should have mastered by the time they enter medical school and competencies in the same topical areas that medical students should master before receiving their MD degrees. In addition, the AAMC Behavioral and Social Sciences Foundations for Future Physicians panel recently released their report “Behavioral and Social Sciences Foundations for Future Physicians” (1). In light of these guidelines, we propose developing a new major, Medical Biology, administered by the Department of Biology at USD to make the premedical curriculum more relevant in preparing tomorrow’s physicians and other health-care professionals for entry into doctoral-level programs while at the same time providing students with a broad background in the Biological Sciences. The proposed major in Medical Biology represents a roadmap for meeting the competencies for students entering doctoral-level programs in medicine recommended by the AAMC/HHMI reports. This degree program will also provide a broad background and excellent training in the biological sciences for students interested in pursuing graduate or professional degrees in health care, biotechnology, physiology, and cellular and molecular biology.

The proposed Medical Biology major differs from any major currently offered at USD and in the Department of Biology. The curriculum emphasizes courses from the current Cell & Molecular and Physiology & Function groupings, deemphasizing organismal biology and diversity courses, to a larger degree than the current Molecular Biology & Physiology specialization in Biology. In addition, the proposed major includes specific courses in Human Anatomy and Human Physiology. The proposed Human Anatomy course would include a cadaver-based anatomy laboratory to provide students with hands-on experience with dissection and in situ anatomical training. The Advanced Human Physiology course is specifically designed as...
NEW MEDICAL BIOLOGY MAJOR

Biology Department to offer new major in Medical Biology

A new B.S. degree in Medical Biology, housed in the Biology Department, will be offered beginning in Fall 2012. The new major results from collaboration between the College of Arts & Sciences and the Sanford School of Medicine at USD to address the needs of premedical students in the 21st century. The curriculum is based on recent reports by the Association of American Medical Colleges and the Howard Hughes Medical Institute, which identified competencies in the natural and social sciences that students should master before they enter medical school, as well as competencies that they should master by the time they graduate with an MD degree. In light of these guidelines, and given that medical schools across the nation (including at USD) are expected to adopt them, USD has developed a Medical Biology major that will be more relevant in preparing tomorrow’s physicians and other health-care professionals for entry into graduate programs while at the same time providing students with a broad background in the biological sciences. Courses in the Medical Biology major will be offered by the Biology Department and by the Sanford School of Medicine and will enable students to add some focused coursework in human medical science to the broad training they currently receive in Biology.

Due to the relatively high number of credit hours required for the major (68–70 credits, or ~58% of the 120 credits required for a baccalaureate degree), the simplest minor for a Medical Biology major is the Interdisciplinary Sciences minor already allowed in the College of Arts and Sciences. To facilitate this, the College of Arts and Sciences amended the requirements for the Interdisciplinary Sciences minor to include the Principles of Biochemistry course. Thus, Medical Biology students automatically earn their minor within the major. Nonetheless, a number of Medical Biology majors still opt to complete additional coursework for a second minor, often choosing Chemistry, Psychology, or Spanish. Chemistry and Psychology are particularly appealing because the Medical Biology program requirements already include several courses or electives in these disciplines, so fewer additional courses are needed to complete the minor.

During the launch of the Medical Biology major in the fall semester of 2012, 20 students enrolled, including 6 continuing students who transferred into the new major. An additional 55 students added the Medical Biology major by spring 2013, an inquiry-based integrative course and meant as a capstone experience that uses team-based, problem-based and case-based learning approaches similar to formats commonly used in graduate and professional schools.

Other modifications were described in separate paragraphs justifying the changes in the science curricula. The Committee recommended one semester of organic chemistry (expanded from 4 to 5 credit hours) with a laboratory followed by a new one-semester chemistry course about the Structure and Function of Biomolecules without a laboratory. A Cell Biology course emphasizing the chemistry of biomolecules in cellular function would be allowed as an alternative to the Structure and Function chemistry course to give a wider range of options and scheduling flexibility to students. The Principles of Biochemistry course would be modified to concentrate on metabolism and other topics most appropriate for medical students and continue to be taught by a medical school faculty member. The most pertinent courses in general education for achieving the competencies would be added to the 4-yr major course list. These included Calculus, General Psychology, Introduction to Sociology, and Biomedical Ethics courses. As electives within the major, Medical Biology students can take a number of biology courses or microbiology, pharmacology, physiology, public health, epidemiology, or biochemistry laboratory courses (taught by medical school faculty members) or psychology courses (taught by arts and science faculty members). Since the Department of Biology already had two departmentally designated specializations for its majors, it was decided that a new Medical Biology major be considered by the biology faculty to be added immediately so that students majoring in biology would be able to adjust their curricular requirements to the new major before the conclusion of the final approval process. The final course curriculum for the new Medical Biology major approved by the South Dakota Board of Regents and initiated in the fall of 2012 is shown in Table 4.

DISCUSSION

Since the University of South Dakota was extremely interested in the new Medical Biology major for recruitment purposes, a press release was distributed on July 16, 2012 (after approval by the SD Board of Regents) announcing the new major, and the new major was featured as news on the main web page of USD. The text of the press release was:

Table 4. Requirements for the BS degree in Medical Biology (general education and college requirements, 41–43 credit hours)

<table>
<thead>
<tr>
<th>Biology Courses</th>
<th>Chemistry Courses</th>
<th>Physics Courses</th>
<th>Other Natural Science Courses</th>
<th>Social Science/Humanities Courses</th>
</tr>
</thead>
<tbody>
<tr>
<td>General I (laboratory)</td>
<td>General/Honors I (laboratory)</td>
<td>Introductory or University I (laboratory)</td>
<td>Human Gross Anatomy</td>
<td>Biomedical Ethics</td>
</tr>
<tr>
<td>General II (laboratory)</td>
<td>General II (laboratory)</td>
<td>Introductory or University II (laboratory)</td>
<td>Principles of Biochemistry</td>
<td>General Psychology</td>
</tr>
<tr>
<td>Biostatistics (laboratory)</td>
<td>Organic I (laboratory)</td>
<td>Biomolecules*</td>
<td>Advanced Human Physiology I</td>
<td>Introduction to Sociology</td>
</tr>
<tr>
<td>Genetics Molecular Biology Seminar</td>
<td>Cell Biology*</td>
<td>Intro Physiology†</td>
<td>Calculus I (laboratory)</td>
<td></td>
</tr>
</tbody>
</table>

9 credits of required electives in biology, biochemistry, chemistry, microbiology, pharmacology, physiology, public health, epidemiology, or psychology

*Cell Biology or Structure and Function of Biomolecules are prerequisites for Principles of Biochemistry. †Comparative Physiology, Mammalian Physiology, or Environmental Physiology of Animals are prerequisites for Advanced Human Physiology.

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Due to the relatively high number of credit hours required for the major (68–70 credits, or ~58% of the 120 credits required for a baccalaureate degree), the simplest minor for a Medical Biology major is the Interdisciplinary Sciences minor already allowed in the College of Arts and Sciences. To facilitate this, the College of Arts and Sciences amended the requirements for the Interdisciplinary Sciences minor to include the Principles of Biochemistry course. Thus, Medical Biology students automatically earn their minor within the major. Nonetheless, a number of Medical Biology majors still opt to complete additional coursework for a second minor, often choosing Chemistry, Psychology, or Spanish. Chemistry and Psychology are particularly appealing because the Medical Biology program requirements already include several courses or electives in these disciplines, so fewer additional courses are needed to complete the minor.

During the launch of the Medical Biology major in the fall semester of 2012, 20 students enrolled, including 6 continuing students who transferred into the new major. An additional 55 students added the Medical Biology major by spring 2013,
mostly transferring from the Biology major or from premedical tracking status with no declared major. Due to the overlap in elective coursework between the Molecular Biology and Physiology specialization of Biology and the new Medical Biology major, some of those students who transferred as upper-division students only needed to take the newly created Human Gross Anatomy course and a few other courses outside the Biology major, such as Advanced Human Physiology and Biomedical Ethics courses, to complete the Medical Biology major without significant delays to their graduation dates. One such student graduated in May 2013 with the first BS degree in Medical Biology awarded at USD. Two additional Medical Biology majors graduated in May 2014. At the beginning of the second year of the major, a total of 182 students enrolled as Medical Biology majors, including 97 students who were new to USD and a further 29 students who transferred from other programs at USD. By the third year of the Medical Biology major, the total number of students had grown to 237 (Fig. 1).

While the Medical Biology major has proven to be attractive to students, not all choose to remain enrolled as majors. A significant number have dropped the major (Fig. 1), usually transferring to other science, technology, engineering, and mathematics majors or prehealth profession majors. No formal surveys have been conducted to assess the reasons for changing from the Medical Biology major to another major. Some anecdotal reasons include changes in the students’ professional goals, the rigor of the major, and difficulty in scheduling some required courses.

In the Advanced Human Physiology class during the fall semester of 2014, the number of junior or senior Medical Biology majors reaching their upper-division courses rose to 22 students, with 3 other student majors enrolled in the class. Approximately 30 Medical Biology majors should be ready to graduate in May 2015. Thus, careful tracking of the success rates for these student majors in being accepted and matriculating into professional schools should be done to assess the impact of the new major on successfully preparing tomorrow’s healthcare professionals.

Physiology in the medical biology curriculum. As noted previously, the Committee identified one of the weaknesses of the 2011 suggested premedical curriculum to be a limited background in physiology due to a minimal requirement of only 100- to 200-level physiology course material, although most premedical students did enroll in upper-level animal physiology courses, as at least 6 credit hours of upper-division physiology courses were required for the Molecular Biology and Physiology specialization of the Biology major. These physiology courses, however, were primarily content-based, rather than inquiry-based, courses, and many were without laboratory components. Another weakness was that the students had limited opportunities for inquiry-based and team-based learning in their upper-division science courses and could complete a premedical degree program without participating in inquiry-based and team-based learning exercises. A third underlying weakness was that most of the courses in the biology curriculum do not specialize in the anatomy and physiology of humans. Thus, the new Human Gross Anatomy cadaver-based course and the existing Advanced Human Physiology course (both taught by medical school faculty members) were added as requirements for the Medical Biology major. Due to restrictions on the number of cadavers available for the Human Gross Anatomy course, enrollment is limited to Medical Biology or Health Science majors with at least 60 credit hours of coursework and a grade point average of 3.0 or higher. Prerequisites for the Advanced Human Physiology course are one of three physiology courses in the biology curriculum (Comparative Physiology, Environmental Physiology of Animals, or Mammalian Physiology; all at the 400 level) and one semester of General Chemistry.

The Advanced Human Physiology course (PHGY 420) required for the Medical Biology majors was not a new course at USD but was a previous elective course for Biology majors interested in health professional careers. There were already components in the course that supported SFFP competencies: an understanding of scientific inquiry, basic physical and chemical principles applied to living systems, contributions of biomolecules to cell function, principles of the function of organs and organisms, and how organisms sense and control their internal environments. Thus, the physiologist who taught the course was able to convince Committee members and the administration that the course should be required and that its timing would allow it to serve as a capstone experience for the majors near the completion of their undergraduate education and the beginning of their professional education.

Fig. 1. Enrollment in the Medical Biology (MBIO) major at the University of South Dakota. Each bar shows the total number of students enrolled as MBIO majors, subdivided as students who were new to the university (new and transfer) and those who were continuing students (including those who transferred into MBIO from another major) during each semester for which we have data. F, fall; Sp, Spring. Numbers of students who dropped the major are shown as negative values.
The required semester of Advanced Human Physiology was designed to help preprofessional students (who are likely to need to take another physiology course in graduate or professional school) to learn physiology not merely as content to be committed to memory but as basic concepts and consequences of normal and disease physiology. The course is targeted to a deeper understanding of cardiovascular, renal, and respiratory physiology by team-based learning, incorporating readiness assessment quizzes for reviewing the basic physiology from textbook chapters. The course was designed to concentrate on these three systems due to their complexity and interrelatedness, while studying only three systems in a 15-wk semester allows for a deeper understanding of the physiology concepts. The required textbook for the course is Silverthorn’s *Human Physiology: An Integrated Approach* (8), with access to Mastering A&P web resources (6).

During the fall semester of 2014 with an enrollment of 25 students, semester-long teams of 4–5 students carried out a number of medical laboratory experiments using PowerLab systems, which offered physiology measurements in healthy individuals (the students) and videotaped case studies with real patients. During the extended class period, teams also conducted several of the PhysioEx online experiments in addition to working on various case-based and problem-based assignments with their team or a partner (6). Each system block also required a team-based project related to the physiological concepts of the block. For example, in the cardiovascular block, students performed different cardiovascular Labtutor modules (AD Instruments) and taught the other teams what they learned. In the renal block, students prepared a teaching module for physiology and pathophysiology for a 90-min high school science class and taught their module to local high school students. In the respiratory block, students chose a project and prepared to teach it to their classmates (several teams chose case studies of respiratory diseases, one team prepared a brochure on secondhand smoke for college students, one team prepared a brochure on children’s asthma for their parents, and one team designed a presentation comparing the hazards of tobacco vs. marijuana smoking).

Grades for the course were mostly determined by individual student scores on open-resource long-essay take-home exams with most of the questions written as case vignettes. Students were given at least 2 wk to work on the 10–12 questions on each exam. Informally, students in the course have appreciated the many options for learning with the team-based approach and have credited the individual essay exams as being excellent learning experiences for them.

While the Advanced Human Physiology course has been offered since the spring of 2010, the number of students in the class ranged from 2 to 14 students each of 5 semesters (average: 9 students) until the recent class of 25 students. Only anecdotal information is available from students who completed the course and have subsequently enrolled in professional schools. Several of those students who are still at the university in professional programs have stated that the course approach helped them understand the basic concepts of physiology and be better prepared for their physiology courses in professional schools. Simultaneously to the launching of the Medical Biology major at USD, medical school faculty members of SSOM designed an integrative interdisciplinary curriculum for the basic science training of the medical students. The new medical school curriculum begins with two courses to help students learn the foundational material for a systems-based approach followed by systems blocks with integrated physiology, microbiology, pathology, pharmacology, and immunology components. Currently at this medical school, incoming students experience fewer lecture-based and more student-centered learning opportunities throughout the new curriculum and a number of team-based learning modules. Thus, two classes of medical students are now being taught by similar pedagogy to that experienced by the USD Medical Biology majors in Advanced Human Physiology. However, none of the medical students in these two classes had previously taken USD’s Advanced Human Physiology course, so prior experience with team-based learning opportunities cannot yet be evaluated.

**Challenges in creating the Medical Biology major.** During the discussions of the curriculum for the new Medical Biology major, the Committee worked through several concerns and disagreements among Committee members. These concerns largely centered on the following: 1) what courses needed to be required or allowed to count for elective courses, 2) content to be included within the required courses for the Medical Biology major (and how that related to the content needed by non-Medical Biology majors who might also be enrolled in the courses), and 3) impacts on enrollments in standard majors (and minors) offered by Biology and Chemistry departments and enrollments in individual courses within these departments. Enrollment concerns for individual courses included both the potential for underenrollment in courses outside of the Medical Biology major and excessive enrollment in required courses within the Medical Biology major.

Committee members also regularly reported details of committee discussions and proposals at Biology and Chemistry faculty meetings. Proposals for the new major encountered some resistance from Biology and Chemistry faculty members. The expressed concerns centered on three main areas, including the content and enrollment concerns described above and a concern about the new major being a disservice to some students. This latter concern centered on the extra required coursework and relatively prescriptive nature of the Medical Biology major limiting elective options for these students and the potential for limited career choices for Medical Biology majors, especially those who fail to gain admission to medical school after graduation. The disservice to students concern also extended to cases where novel courses in the new Medical Biology major (such as the Structure and Function of Biomolecules course or the absence of standard Anatomy and Physiology courses) did not clearly fit with traditional required courses for medical schools or doctoral programs in other health-related or biology fields (e.g., two semesters of Organic Chemistry or a year-long sequence in Anatomy and Physiology).

One other concern expressed regarding enrollments was that under the new RCM funding model adopted by the University, budget income from offered courses is distributed mainly to the college or school whose faculty members are teaching the course (100% if the major is in the same college or school), with a lesser amount (20%) being distributed to the college or school in which the major is housed, if that is different than the college or school offering the course. In the case of the Medical Biology major, which is housed in the Department of Biology,
an increase in the number of required and elective courses offered by Medical School faculty members relative to a typical Biology major means that the College of Arts and Sciences receives less income from a Medical Biology major than from a typical Biology major. This concern was ameliorated somewhat by projections that the Medical Biology major would increase the overall number of majors in the Department of Biology, which it has, in fact, accomplished (see above), although administrative discussions about the most equitable distribution of funds from these courses is ongoing.

Impact of the Medical Biology major. The Medical Biology major has succeeded in attracting new students to the university and has grown far beyond the optimistic projections set forth in the proposal to the South Dakota Board of Regents, which estimated a total of 130 students in the major by the third year. This rapid program growth has caused some strain to the departments offering required courses, especially the Department of Biology, which offers the majority of the courses. Enrollments in the Medical Biology courses in biology have more than doubled in some cases, necessitating more frequent offerings and larger class sizes. In some cases, additional instructors have been recruited from within and outside the department to help offer required courses more frequently, and the college has allowed additional hiring to alleviate the strain.

There is some concern that faculty members who teach Medical Biology requirements will no longer be able to offer non-Medical Biology courses as frequently as in the past, depriving Biology majors of these elective courses. Similar effects are noted for other departments offering Medical Biology requirements, such as the Department of Philosophy which now offers its Biomedical Ethics course to a packed room of 49 students each semester instead of a small class of 25 students offered once per year, which better facilitated in-class discussions. Scheduling Medical Biology courses requires careful planning, as the required courses come from several departments and scheduling conflicts need to be minimized. Four- and five-year plans were prepared so that students would be guided to sequence their courses and complete prerequisites early in their programs of study. Ideally, these plans should help in minimizing scheduling conflicts, especially conflicts between the lengthy inquiry-based senior-year courses (Advanced Human Physiology and Human Gross Anatomy), and other courses in the major. Scheduling was particularly problematic in the first years, as many students who transferred into the major were not taking courses in the recommended sequence as they tried to “catch up.” Several of these transfer students were accommodated with exceptions and course substitutions so that they could use similar courses taken elsewhere to fulfill Medical Biology requirements. The need for careful scheduling parallels the need for careful advising, as Medical Biology students have fewer electives in the major and need to enroll in required courses each semester or risk falling behind. Scheduling challenges may be aggravated for students who are in the University Honors Program and who, therefore, have other sometimes-restrictive course requirements. These scheduling difficulties have been reduced by frequent communications among the departments and programs involved.

An unanticipated effect of the major was the concern many students had about the Organic Chemistry requirement. Since most medical schools list two semesters of Organic Chemistry with a laboratory as an admission requirement, many students were concerned that the revised requirements of the Medical Biology major (one semester of Organic Chemistry with a laboratory and a second semester of a Biomolecules course without a laboratory) would not be deemed sufficient for admission. Some students opted to take a second semester of Organic Chemistry with a laboratory in addition to the Biomolecules or Cell Biology course, just to be safe. When the Associate Chair of Biology, who administers the Medical Biology major, became aware of this concern, she wrote a letter describing the new major, its revised chemistry requirements, and the rationale for the change. The College of Arts and Sciences sent the letter to medical schools across the country and invited any schools with questions or concerns to respond. To date, no responses detailing any concerns have been received from other medical schools.

Conclusions. The process for creating a new major at USD to address the needs of preprofessional students entering doctoral programs worked well during the year of analysis and discussion. Thus, we would recommend this process to those at other institutions who have similar interests. The representative nature of the Premedical Curriculum Review Committee and the strong support of the two deans helped the discussion and problem solving tasks for the planning of the new major to be fair and open. Thus, the resulting proposal for the required curriculum for the Medical Biology major had already dealt with a number of departmental compromises, which made it more acceptable to the faculty members involved in the new courses.

Having a new Medical Biology major on campus has been attractive for new and transfer students and has been heavily touted in recruiting efforts at USD. However, the rigor of the courses in the major may make it difficult for some students naïve about higher education and the requirements for health professional careers to succeed in the new major. During implementation of the new major, unanticipated high demand for many of the required courses caused some challenges for students and faculty members, as course enrollments rose sharply and departments were forced to offer required courses more frequently to meet student needs. This, in turn, may impact faculty workloads and the availability of course offerings outside the major.

Tracking of graduates with the Medical Biology degree would be helpful in assessing the outcomes of the new major. However, to date, few students have completed their degrees, and only anecdotal information is available about their successes in being accepted into and progressing in professional schools. As more professional schools commit to the recommendations of both the Scientific and Behavioral and Social Science Foundations for Future Physicians and change their undergraduate course requirements, USD students should have an advantage in being ready for professional schools. For further information about the process and the courses described herein, contact Barbara E. Goodman at barb.goodman@usd.edu.

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