

# ASBMB *today*

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## Response to the new MCAT PREMEDICAL CURRICULUM RECOMMENDATIONS

American Society for Biochemistry and Molecular Biology

# Response to the new MCAT

## *ASBMB premedical curriculum recommendations*

BY CHARLES BRENNER AND DAGMAR RINGE

**EDITOR'S NOTE:** At the December Council meeting of the American Society for Biochemistry and Molecular Biology, President Suzanne Pfeffer tasked Charles Brenner with developing premedical curriculum recommendations consistent with the Medical College Admission Test, a revision of which will be rolled out in 2015. Brenner is the Roy J. Carver chair and head of biochemistry at the University of Iowa, a department responsible for teaching undergraduate, graduate, medical and health professional students. After investigating premedical education at his own institution and several others, Brenner turned to Dagmar Ringe, the Harold and Bernice Davis professor of aging and neurodegenerative disease in the departments of chemistry and biochemistry at Brandeis University, to develop recommendations. Ringe also is an organic chemistry and biochemistry textbook author and a former director of the organic chemistry laboratory course at the Massachusetts Institute of Technology. ASBMB encourages your feedback, critique and/or support for the recommendations presented here. Please weigh in at [www.asbmb.org/asbmbtoday](http://www.asbmb.org/asbmbtoday).

Many college students plan their curricula based on medical-school admissions requirements. Enrollment in undergraduate biology, chemistry, physics and calculus courses contributes to science, technology, engineering and mathematics (STEM) literacy even if many premedical students turn to fields other than medicine. The practice of medicine and the education of physicians continue to evolve. In 2008, the American Association of Medical Colleges established the MR5 Committee to revise the MCAT, which was last revised in content areas in 1991, 10 years before the first human genome sequence was available (1–3).

The MR5 Committee has made recommendations that will result in testing of core concepts in biochemistry and social and behavioral sciences, and it also will test critical thinking in ethics and multicultural studies. In preparation for the revised MCAT to be administered in 2015, many colleges of medicine are changing course requirements for students who will begin medical school in 2016 and beyond.

Enrollment in college STEM and other courses is expected

to shift. Universities may need to provide resources to courses on subjects that will be tested in the revised MCAT. Moreover, disciplines already represented in the MCAT may be influenced by the MR5 Committee's recommendations. For example, because biomedical research and practice depend increasingly on statistics, bioinformatics and imaging, the mathematics and physics background provided to premedical students should emphasize these subject areas. Leaders in mathematics and physics will need to determine what material is most germane to future physicians. Similarly, social and behavioral scientists are encouraged to engage in the MR5 process to provide core concepts to premedical students.

The American Society for Biochemistry and Molecular Biology represents thousands of faculty members who teach and conduct research in departments of biology, chemistry, biochemistry and molecular biology. We offer four recommendations for restructuring premedical curricula. If these recommendations are enacted, millions of college students will acquire an education that will improve biomedical literacy and better prepare students for the field of medicine in this genomic, proteomic and metabolomic era. Importantly, these recommendations leave time for students to take classes in social and behavioral sciences and in the liberal arts, which are necessary for the revised MCAT, for medical practice, and for an informed, sensitive citizenry (4).

1. The introductory year of biology should be refreshed (if it hasn't been already) to prepare students in cellular and molecular biology up to and including fundamentals of genetics and biological information transfer.
2. The traditional, two-year sequence of general and organic chemistry should be streamlined to a single year of life-oriented chemistry that focuses on bonding and reactivity of molecules containing carbon, oxygen, phosphorus, sulfur and nitrogen.
3. A one-semester biochemistry course should be required and a two-semester biochemistry



course recommended for premedical students. The material must broadly introduce macromolecular structure/function and cellular metabolism.

4. A single biology, chemistry or biochemistry laboratory course emphasizing research methods and statistics should be required. The content is expected to vary with the department offering the course. For example, a biology laboratory might utilize fluorescent reporters of gene function. A chemistry laboratory might consist of the traditional organic chemistry material or a bioanalytical unit that focuses on quantifying carbohydrate and lipid metabolites. A biochemistry laboratory might characterize enzymes. Each of these methods courses would be expected to cover statistics and data analysis.



We note that a biochemistry course is not offered at every school in which premedical students are enrolled. However, the extensive content survey conducted by the MR5 Committee identified biochemistry as the discipline most important for mastery of the medical school curricula of the future (1). In this age in which gene mutations and metabolic dysregulation are increasingly found to underlie human diseases and differential responses to treatments, enrollment in two semesters of biochemistry is expected to provide students with optimal undergraduate preparation for medical education and training. In turn, better prepared medical students will be able to handle a modernized medical curriculum that will increasingly teach genomics and integrate advanced biochemical concepts into the diagnosis and personalized treatment of disease.

We have initiated conversations with colleagues in departments of biology, chemistry and biochemistry nationwide. Many departments of biology are prepared for these recommended changes because introductory biology is now a molecular course and because capacity exists for increased enrollment in biology laboratory courses.

Chemistry departments, long accustomed to high non-major enrollment in general chemistry, organic chemistry and organic chemistry laboratory, are encouraged to make significant changes to create a nonmajor track in chemistry for life scientists. Though the first semester of general chemistry may be fairly similar to that of a new yearlong sequence in life-oriented chemistry, it will need to get to carbon and carbonyl chemistry more quickly. Moreover, the first semester of organic chemistry, as it is typically taught, does not cover the right material for the new yearlong sequence. Less time will be needed for alkanes, alkenes and alkynes. There will need to be a much earlier introduction to esters and amides. The yearlong chemistry sequence does not necessarily have to put together a macromolecule, though, because biochemistry will do that.

There is a need and opportunity for new textbooks to support life-oriented chemistry. There is also potentially some relief to departments that have been offering organic chemistry laboratory to large numbers of nonmajors. Such students may be distributed into biology or biochemistry labs or offered different chemistry labs, such as bioanalytical chemistry.

At some institutions, biochemistry will be taught by the most chemically oriented member of the biology department or the most biologically oriented member of the chemistry department. This should work fine, so long as the core concepts in macromolecular structure and func-

tion, biological information transfer, enzymatic catalysis, metabolism, and small-molecule signaling are conveyed. We believe that biologists, chemists and biochemists should work together to refine and improve premedical education and also engage with mathematicians, physicists and colleagues in the social sciences, brain sciences and humanities to help prepare the next generation of physicians.

Premedical course recommendations are minima, not maxima. Those physicians who specialize in family practice or end-of-life care may benefit from much more coursework in psychology than is required to take the MCAT. Those who specialize in nuclear medicine might benefit from a triple major in chemistry, biochemistry and physics. The key in developing premedical recommendations is to ensure that a broad range of core concepts is covered and evaluated at the gateway to medical school.

Finally, it has not escaped our attention that some chemistry departments will not be able to provide the resources right away for a nonmajor track that is distinct from course offerings to majors. We provide a potential solution. If a chemistry department were to move to a 1:2:1 sequence for their majors (i.e., one semester of general chemistry, followed by two semesters of organic chemistry, followed by one semester of advanced inorganic chemistry), then students on the life-science track could substitute a semester of biochemistry for the fourth semester of the majors' sequence. However, a redesigned year of life-oriented chemistry that will get to the key carbonyl reactions (e.g., Michael addition, Claisen condensation and aldol condensation) sooner and allow time for a year of biochemistry is expected to provide great benefits to the next generation of biomedical students.

## FREQUENTLY ASKED QUESTIONS

**Is your recommendation of one year of life-oriented chemistry equivalent to the first semester of general chemistry plus the first semester of organic chemistry?** No. Parts of organic chemistry would be incorporated into the first semester of the new two-semester sequence for biomedical students.

**Is there an existing book that teaches life-oriented chemistry in the way you envision this course?** No, but we think that there is an exceptional opportunity for people to write new chemistry textbooks that would satisfy this need.

**Does the shortened time on organic chemistry material mean that the course will focus more on memorization and less on reactivity and reaction mechanisms?** No. Ideally, this course would meet the needs of biochemistry majors and could either be required

or elective for other majors, such as biologists and biomedical engineers. The core competencies from this course should include a strong understanding of chemical reactivity of the classes of compounds encountered in biological systems. It shouldn't be dumbed-down or rote-oriented organic chemistry.

**Do you really think that all college freshmen nationwide are going to be ready for this course?** No, but a substantial fraction of biomedically oriented students, especially those who ultimately matriculate to medical schools, come in with the right background. Students who aren't ready for this course can certainly take the first semester of general chemistry and then either continue with the chemistry majors' track or proceed to the two semesters of life-oriented chemistry.

**Where do these recommendations stand?** Ultimately, colleges and universities that teach premedical students need to decide how to respond to the upcoming changes in the MCAT. We believe that those schools that evolve their coursework and premedical recommendations will benefit by attracting the best and most informed students, by gaining greater integration between departments, and by producing students who are well prepared for graduate and professional schools. We look forward to the dialogue with our colleagues locally and nationally. ☺☺☺

## REFERENCES

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## ENDORSEMENTS

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