

OPINION

A Changing Tide: What the New 'Foundations of Behavior' Section of the 2015 Medical College Admissions Test® Might Mean for Undergraduate Neuroscience Programs

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Each year over 50,000 college students and alumni take the Medical College Admissions Test® (MCAT) and apply for admissions to medical school. After an extensive review process, the MCAT has undergone a major revision in form and content in order to better reflect the competencies medical students will need to be successful in their training and practice. Starting in April 2015, for the first time since the test's inception, the MCAT will include social and behavioral sciences content. The new section of the MCAT exam titled "The Psychological, Social and Biological Foundations of Behavior" will test pre-health competencies that combine content knowledge with scientific inquiry and reasoning skills. Anticipating growing interest in curriculum related to the new competency based content on the exam, the AAMC (Association of American

Medical Colleges) established the Pre-health Collection within MedEdPORTAL's iCollaborative, a free repository of teaching resources. This online space gives faculty members the opportunity to share access to instructional resources in order to prepare or revise courses to include pre-health competencies. As a result of the increased content related to mind-body connections, undergraduate pre-medical students will be more likely to enroll in neuroscience courses to learn these competencies, or declare neuroscience majors, as the typical neuroscience major course requirements now meet most of the suggested pre-requisite competencies for medical school.

Key words: MCAT 2015; teaching resources, curriculum; pre-medical education

The Medical College Admissions Test® (MCAT), which is required for admission to the vast majority of medical schools in the United States and Canada, has recently undergone its most extensive revision in the 85 year history of the exam. The Association of American Medical Colleges (AAMC) and the Howard Hughes Medical Institute (HHMI) formed a committee to evaluate the premedical and medical school science curricula. Their 2009 report "Scientific Foundations for Future Physicians" prompted the AAMC MR5 committee (Fifth Comprehensive Review of the MCAT) to recommend substantial changes to the exam, which were approved by the AAMC board of directors in Spring, 2012. The new concepts tested on the exam are meant to reflect the scientific content identified as most important for incoming medical students by the AAMC-HHMI committee, recent medical advances, changes in health care structure and delivery, and the increasing diversity of the population (AAMC-HHMI, 2009; AAMC, 2010).

Broadly speaking, the revision aims to 1) shift the academic focus away from pre-requisite undergraduate courses and toward specific scientific competencies; 2) test critical reasoning skills in scientific contexts; 3) acknowledge the importance of the bio-psycho-social model of health, and 4) recruit future physicians with more diverse backgrounds and skill sets (Kirch et al., 2013). The MCAT revision emphasizes ten foundational scientific concepts and seven analytical and critical reasoning skills (Table 1).

The computer based exam will now consist of four

Health is a product of the interactions among biology, genetics, behavior, relationships, cultures, and environments. Some of medicine's most promising frontiers for improving health explore the realms of human behavior and social science. More and more disease states cannot be addressed without attention to the behavioral or social factors that cause them, erect barriers against treating them, or can ameliorate or even cure them.

- Preamble to the AAMC Behavioral and Social Science Foundations for Future Physicians (2011)

scored sections: Chemical and Physical Foundations of Biological Systems; Biological and Biochemical Foundations of Living Systems; Psychological, Social and Biological Foundations of Behavior, and Critical Analysis and Reasoning Skills. The Chemical and Physical Foundations section corresponds to the old "Physical Sciences" section, but includes less organic chemistry content. The Biological and Biochemical Foundations section corresponds to the old "Biological Sciences" section, but includes more biochemistry content. The old "Verbal Reasoning" section has been eliminated and replaced with the Critical Analysis and Reasoning Skills section, which draws on passages from the social sciences and humanities, but is designed to be self-contained. The Psychological, Social and Biological Foundations of Behavior section is entirely new, and tests examinees' knowledge of concepts and critical reasoning skills pertaining to biological, social, and behavioral determinants of behavior.

MCAT 2015 Foundational Concepts	
1.	Biomolecules have unique properties that determine how they contribute to the structure and function of cells, and how they participate in the processes necessary to maintain life.
2.	Highly-organized assemblies of molecules, cells, and organs interact to carry out the functions of living organisms.
3.	Complex systems of tissues and organs sense the internal and external environments of multicellular organisms and, through integrated functioning, maintain a stable internal environment within an ever-changing external environment.
4.	Complex living organisms transport materials, sense their environment, process signals, and respond to changes using processes that can be understood in terms of physical principles.
5.	The principles that govern chemical interactions and reactions form the basis for a broader understanding of the molecular dynamics of living systems.
6.	Biological, psychological, and socio-cultural factors influence the ways that individuals perceive, think about, and react to the world.
7.	Biological, psychological, and socio-cultural factors influence behavior and behavior change.
8.	Biological, psychological, and socio-cultural factors influence how we think about ourselves and others.
9.	Social and cultural differences influence well-being.
10.	Social stratification affects access to resources and well-being.
Scientific Inquiry & Reasoning Core Skills	
1.	Knowledge of scientific concepts and principles
2.	Scientific reasoning and evidence-based problem solving
3.	Reasoning about the design and execution of research
4.	Data-based and statistical reasoning
Critical Analysis & Reasoning Core Skills	
1.	Foundations of comprehension
2.	Reasoning within the text
3.	Reasoning beyond the text

Table 1. Core scientific competencies and skills of the 2015 MCAT (AAMC, 2010).

Individual subscores on the four sections will range from 118 to 132, with an estimated mean of 125. Total combined scores will range from 472 to 528, with an estimated mean total score of 500. Scores will be reported with percentile rankings and confidence bands. The testing time has been increased from 3.3 to 6.25 hours of examination, with a total administration time of 7.5 hours to include breaks for refreshments and physical relief. Compared to the old version of the MCAT, there will also be more working time per question, which might help English language learners and individuals with learning disabilities better cope with the fast paced timing of the exam.

2015 MCAT NEUROSCIENCE CONTENT

The AAMC suggests that an academic schedule including a two semester introductory biology sequence, five semesters of chemistry (two general, two organic, one biochemistry), two semesters of physics, and a semester each of psychology and sociology will meet most of the prerequisite competencies (AAMC, 2015). Specific course pre-requisites vary by medical school; some do not require biochemistry, and most strongly recommend or require upper level electives in biology and a course in statistics. The AAMC released a free course-mapping spreadsheet tool for pre-health advisors and administrators to use to help clarify which undergraduate courses provide the best match for specific foundational concepts (<https://www.aamc.org/students/advisors/mcat-advisors/423032/course-mappingtool.html>). The AAMC is encouraging all colleges and universities to customize this spreadsheet to help pre-medical students identify courses which would best help them gain mastery of these concepts, and subsequently be better prepared for the MCAT.

Although the AAMC does not mention 'neuroscience' *per se* in any of the MCAT 2015 materials, succeeding in a neuroscience course would seem to be excellent preparation for many of the foundational concepts on the 2015 MCAT. Table 2 highlights the major neuroscience foundational concepts from the course-mapping tool. Of the 149 topics listed in the spreadsheet, 30 (20%) would likely be covered in a foundational neuroscience or physiological psychology course.

A review of specific foundational concepts and content categories demonstrates that there is an unequal distribution of foundational concepts by recommended course sequence. For example, the AAMC course mapping tool identifies 69 subtopics which should be covered by the five semesters of chemistry (~14 concepts per course). By comparison, there are 36 subtopics identified to be covered by a single psychology course. Seventeen of these psychology concepts (e.g., cognition, the senses, associative learning, language, self-presentation, etc.) are also listed under the two-course introductory biology sequence, and would likely receive extensive coverage in a neuroscience course. One of these 36 psychology concepts, 7A-Biological Bases of Behavior, has an extensive sub-subtopic listing which includes the nervous system, neuronal communication, neurotransmitters, the endocrine system, behavioral genetics, and human physiological development. It is highly unlikely that a single introductory psychology course (even with assistance from the days or weeks introductory biology courses might spend on the biological bases of behavior) could cover these topics in sufficient depth to prepare a student for the 2015 MCAT exam.

TEACHING RESOURCES

Anticipating growing interest in revising curriculum related to the new competency based exam, the AAMC established the Pre-health Collection within MedEdPORTAL's iCollaborative, a free, open-access

Foundational Concept	2015 MCAT Neuroscience Related Content	New to MCAT	BIO	BC	GC	PSY
1C	Evolution		X			
1D	Hormonal Regulation & Integration of Metabolism	X		X		
2C	Biosignalling (oncogenes, apoptosis)	X		X		
2C	Mechanisms of Development		X			
3A	Nervous System: Structure and Function		X			
3A	Nerve Cell		X			
3A	Electrochemistry				X	
3A	Biosignalling (gated ion channels)	X		X		
3A	Endocrine System: Hormones and Their Sources		X			
3A	Endocrine System: Mechanisms of Hormone Action		X			
4C	Specialized Cell - Nerve Cell		X			
6A	Sensory Processing		X			X
6A	Vision		X			X
6A	Hearing		X			X
6A	Other Senses	X	X			X
6A	Perception	X				X
6B	Attention	X				X
6B	Cognition	X	X			X
6B	Consciousness	X	X			X
6B	Memory	X	X			X
6B	Language	X	X			X
6C	Emotion	X	X			X
6C	Stress	X	X			X
7A	Biological Bases of Behavior	X	X			X
7A	Psychological Disorders (DSM5)	X	X			X
7A	Motivation (Drives)	X	X			X
7C	Habituation and Dishabituation	X				X
7C	Associative Learning	X	X			X
7C	Observational Learning	X				X
8C	Social Behavior (altruism, aggression, mate choice)	X	X			X

Table 2. This table is adapted from the freely available AAMC course-mapping tool, which plots core competencies for the ten foundational concepts against the classes in which these subjects are most likely to be taught. The 30 (of 159) content categories most directly related to neuroscience are listed here; 18 of these were not included in previous versions of the MCAT. BIO- 2 course introductory biology sequence, BC- 1 course biochemistry course, GC- 2 course general chemistry sequence, PSY-1 course introductory psychology sequence. Columns for organic chemistry, physics, and sociology are not included in this table.

repository of teaching resources (www.mededportal.org/icollaborative/pre-health). This online space gives undergraduate faculty members the opportunity to share access to instructional resources that support curriculum innovation (Jakubowski and Zapanta, 2013). Faculty members, advisors, and students can post classroom activities they have authored or refer a resource authored by someone else. The Pre-health Collection already includes over 250 instructional resources that are categorized by intended audience, instructional and assessment methods, and foundational concept covered. The AAMC, with partners in the Robert Wood Johnson

Foundation and the non-profit educational organization The Khan Academy, have also posted many short video tutorials for the new MCAT exam, indexed by pre-health competency subtopic. Although the teaching resources posted on this site have been briefly screened for content, they are not considered peer-reviewed.

CURRICULUM IMPLICATIONS

In the last two decades, undergraduate neuroscience programs have experienced exponential rates of growth in both the number of institutions offering neuroscience programs and the total number of neuroscience degrees

conferred (Ramos et al., 2011). The changes in the MCAT design are likely to spur this growth even more. Premedical students might be drawn to enroll in a neuroscience course to bolster their understanding of pre-health competencies regarding the biological basis of behavior, or declare a neuroscience major because the breadth of course requirements in typical programs (as outlined in Wiertelak and Ramirez, 2008) aligns so well with the scientific competencies and skills emphasized by the MCAT revision. The emphasis in most neuroscience programs on reading primary literature, practicing the scientific method, and applying quantitative analyses and interdisciplinary approaches to diverse problems would also seem to prepare students well for the new Critical Analysis and Reasoning Skills section of the exam.

Estimates reveal that for every 100 students who take a majors-level introductory chemistry course, eight will apply to medical school, and only three will become physicians (Brenner, 2013). Because neuroscience and psychobiology majors are included under the AAMC umbrella reporting classification “biological sciences,” it is hard to know exactly how many neuroscience majors apply and matriculate to medical school each year. More broadly, it is hard to know exactly how many undergraduate neuroscience degrees are conferred each year, but recent estimates put the numbers at least 2,000 (Ramos et al., 2011). To what extent should colleges and universities feel compelled to revise their curriculum to better match the MCAT competencies for the minority of students who will apply to medical school?

Dr. Robert Alpern, Dean of the Yale College of Medicine, et al. enthusiastically suggested that “one of the most direct benefits of the proposed changes will be that undergraduate colleges will have the freedom to develop innovative curricula, because they will no longer have to teach the traditional premedical courses. This will provide the option for faculty to teach in a more interdisciplinary and interdepartmental manner” (2011, p 34). Likewise, Dr. Darrel Kirch, president of the AAMC, et al. argued that the new MCAT “is a call for baccalaureate faculty to develop multidisciplinary, competency-based courses that make it possible for prospective medical students to prepare efficiently for the exam and medical school” and noted that faculty at “Harvard, Purdue, University of Texas, University of Maryland, and elsewhere are already developing innovative undergraduate courses to achieve this goal” (2013, p. 2244). Whether a shift to this type of innovative, interdisciplinary instruction at the undergraduate level is the inevitable consequence of an increasingly transdisciplinary scientific community, or an unrealistic expectation for academic institutions historically siloed by department and division remains to be seen.

REMAINING QUESTIONS

The previous version of the MCAT had robust validity for predicting unimpeded success in medical school (Dunleavy et al., 2013). Aside from important queries about the reliability and validity of the new exam structure, questions about the implications of such a radical restructuring of the MCAT have inundated the academic advising community.

How much will medical school admissions committees use performance on the social and behavioral section when considering admissions decisions? Will weaker scores on the chemistry section be just as detrimental to the admissions process as weaker scores on the social sciences or critical analysis sections? The AAMC does publish mean MCAT subscores for both applicants and matriculants, but it will likely be a few years before regression analyses are conducted to answer this question. (Author’s note: I have had off-the-record conversations with admissions officers who said that their medical school admissions committee plans on focusing primarily on the scores from the chemistry and biology sections and undergraduate GPA when considering academic aptitude.)

What are the additional financial and time burdens for pre-med students? Dr. Kirch suggests that the shift from prerequisite courses to scientific competencies “should translate into broadened academic options for applicants who will have greater freedom in how they structure their undergraduate course work and personalize their pathway to medical school” (2013, p. 2244). However, without significant and quick changes to most undergraduate degree programs, the revisions to the MCAT effectively raise the number of prerequisite courses by at least three (psychology, sociology, and biochemistry), with additional courses in neuroscience, statistics, and research methods providing important support for students. This additional semester’s worth of work might further limit the academic options for students whose financial constraints dictate that they complete college in the most efficient and least expensive way possible.

The exam itself cost will cost \$300 per administration, although reduced registration fees are available for students who meet certain income designations. The official AAMC guidebook and online practice questions cost \$35 and a full-length online sample test from the AAMC costs \$25. Approximately half of students who take the MCAT use a commercial test preparation service to prepare for the exam; these courses typically range between \$1800 - \$3000. Data are not provided by the AAMC regarding what percent of applicants versus matriculants use commercial test preparation services, or whether students from higher family income brackets are more likely to pay for these commercial services. Therefore, it is unknown to what degree these test-prep services confer an advantage, and/or further perpetuate economic disparities in matriculation to medical school. Approximately half of medical students hail from families whose annual income is in the top quintile of the U.S. distribution (> \$91,705, using 2005 Census estimates) whereas only 5% of medical students’ family incomes rank in the lowest quintile (< \$19,178; Jolly, 2008).

Will diversifying the MCAT exam result in a more diverse population of medical students, both in terms of demographics and intellectual strengths? The AAMC certainly recognizes that the “changing demographics of the patient population necessitate a diverse, culturally competent, and broadly educated physician workforce” (Kirch et al., 2013, p. 2244). But will a young sociology

major, upon learning that economic disparities in health is a topic on the MCAT exam, be more motivated to pursue medicine? Will the students who perform best on standardized exam content covering social and cultural determinants of health also be the ones most likely to apply that knowledge in caring and compassionate ways as physicians? Will the demographics of who applies and who is accepted to medical school better reflect the cultural and economic diversity of the population?

The answers to these important questions, and others, will likely take years to determine. In the meantime, prepare to see more pre-medical students enrolling in neuroscience courses.

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Received January 13, 2015; revised March 02, 2015; accepted March 06, 2015.

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