The NEW ENGLAND JOURNAL of MEDICINE

Perspective
JULY 17, 2008

BECOMING A PHYSICIAN

Relevance and Rigor in Premedical Education

Jules L. Dienstag, M.D.

In recent decades, scientific knowledge has changed dramatically, once-settled scientific principles have been replaced by more sophisticated concepts and entirely new disciplines, and parallel changes have occurred in medical practice and health care delivery. In the face of these new realities, medical school curricula have had to adapt. Yet despite these sweeping changes, including the permeation of most areas of medicine by molecular and cellular biology and genetics, requirements for admission to medical school have remained virtually unchanged for many decades.

Ironically, though many of today's high-school students are learning advanced science and mathematics that my generation studied in college or medical school, U.S. medical schools continue to devote precious time in the preclinical years to elementary-level biochemistry, cell biology, and genetics. With so much new scientific material to cover, medical school faculties must struggle to fit it all in while addressing the needs of students with widely varied levels of science preparation. Pressure on faculty members teaching preclinical courses is intensified by the truncation of the preclinical program at many medical schools to allow for earlier entry into the clinical curriculum. At the same time, many medical schools, recognizing the value of student scholarship, are adding a requirement for an in-depth scholarly project that must also fit into a 4-year curriculum.

Some view the current premedical science requirements — 1 year of biology, 2 years of chemistry (especially organic chemistry), 1 year of physics, and, in some schools, 1 year of mathematics — as a necessary gauntlet that thins out the applicant pool. Unfortunately, current college courses that fulfill admissions requirements are not adequately focused on human biology; the topics covered in many courses in chemistry, physics, mathematics, and even biology are so removed from human biologic principles that they offer little value to the premedical — or advanced human biology — student and steal time and attention from more relevant science preparation. Does a student, for example, really need a full year of organic chemistry to prepare for the study of biochemistry? Moreover, premedical science courses often fail to achieve sufficient rigor to prepare stu-

Premedical Students Receiving an Anatomy Lesson.

Underwood/Corbis

dents for tackling the sciences fundamental to medicine at the advanced molecular level now required. We should expect a higher standard from students who wish to pursue medicine in an era in which genomics and informatics will revolutionize biomedical science and health care.

No one is arguing for more time in college devoted to premedical science courses; rather, I support greater efficiency and a tighter focus on science that "matters" to medicine. In addition, because of the growing commonality of language among scientific disciplines, and because human beings are complex organisms whose discrete systems are linked intricately and elaborately within the body and modified profoundly by external influences, we need to teach in ways that reflect this complexity and that stimulate students to synthesize information across disciplines. Unfortunately, asking faculty members to undertake such synthesis defies the long-sacred compartmentalization of disciplines into departmental silos. Such isolation among disciplines has already begun to change, and many medical schools have added new departments of systems biology, which focus on this complexity and the interdependence and interaction among different body systems. A sick patient does not represent a biochemistry problem, an anatomy problem, a genetics problem, or an immunology problem; rather, each person is the product of myriad molecular, cellular, genetic, environmental, and social influences that interact in complex ways to determine health and disease. Our teaching, in both college and medical school, ought to echo this conceptual framework and cut across disciplines.

In 2006, we at Harvard Medical School launched a new, more cross-disciplinary, integrated curriculum, one of whose goals was to amplify reinforcement of basic and population sciences during the clinical years. In preparation for curriculum reform, a working group reassessed medical school admission requirements to determine whether premedical education prepared students adequately for our new curriculum (see the Supplementary Appendix, available with the full text of this article at www.nejm.org). This group advocated for increased rigor of undergraduate science preparation and a refocusing on more biologically relevant and interdisciplinary science courses that demonstrate and build on complementary concepts in biology, chemistry, physics, and mathematics. To fulfill expectations for more advanced premedical science preparation, college science courses ought to foster scholastic rigor, analytic thinking, quantitative assessment, and analysis of complex systems in human biology; their goal should be to help students acquire a different, larger, more molecularly oriented and scientifically sophisticated knowledge base than that mastered by previous generations of premedical students.

Many colleges have successfully incorporated cellular and molecular biology and genetics into introductory biology courses. They have been less successful, however, at increasing the relevance and rigor of premedical chemistry and math requirements. Instead of the current chemistry sequence, colleges could expose premedical students to general chemistry, organic chemistry, and biochemistry in a 2-year sequence that provides the foundation for the study of biologically relevant chemistry. Ideally, instead of devoting time to a second semester of organic synthesis, college students could take a seamless sequence of preparatory organic chemistry and basic principles of biochemistry (especially protein structure and function), completing the study of introductory biochemistry before medical school and building a foundation for medical school courses that begin from and reach higher plateaus.

To provide premedical students with the computational skills required for the advanced study of biology, college math courses should focus on biologically relevant algebraic and trigonometric quantitative skills; require familiarity with calculus and the mathematical description and uncertainties of dynamic biologic systems but not divert attention to the derivation of theorems that have little relevance to biology; and provide adequate grounding in probability and statistics, which are required for an understanding of the scientific and medical literature.

The college years should not be designed primarily to prepare students for professional schools. College should be a time to explore and stretch academically and intellectually; to engage creatively in an expansive liberal arts education encompassing literature, languages, the arts, humanities, and social sciences; and to prepare for citizenship in society. Included in this foundation should be analytic, writing, and communications skills; fluency and a nuanced facility in English; mastery of a foreign language; the basis for understanding human behavior, appreciating societal structure and function, achieving cultural awareness, and facilitating a habit of lifelong self-education; and in-depth, sustained, independent study, which fosters deep reflection, an active role in acquiring knowledge, and scholarly ownership in an area of inquiry. How do we accomplish all this and encourage attention to other scholarly avenues without rendering the time commitment for science courses too burdensome? A reasonable prescription for efficiency and economy would involve refocusing, increasing relevance, setting a higher standard, and encouraging the design of more interdisciplinary premedical science courses.

A sick patient does not represent a biochemistry problem, an anatomy problem, a genetics problem, or an immunology problem.

Responding to the same concerns about premedical science education, the Association of American Medical Colleges and the Howard Hughes Medical Institute have undertaken a joint, comprehensive assessment of the continuum of premedical and medical science education. Themes likely to be included in their recommendations are the importance of introducing synergy and efficiency through cross-disciplinary and biologically relevant teaching; of educating "inquisitive" physicians, who understand not only medical knowledge but also how it is acquired; and of establishing a habit of scientific thought on which to build the practice of medicine. The recommendations are likely to favor scientific competencies over specific discrete courses, implying that premedical requirements for rigid, 1-to-2-year, discipline-specific science courses should give way to more creative and innovative courses that span and unite disciplines, offering a glimpse of the way biologists and physicians actually navigate real-life problems.

Creating such new, cross-disciplinary science courses may well be difficult for colleges, which vary in the availability of resources, depth of faculty, and political will of traditional departments to address these curricular demands. Medical school admissions committees, for their part, will face difficulties in assessing who has met admissions requirements focused more on competencies than on courses. If both colleges and medical schools succeed, however, students will begin medical school with more advanced and relevant preparation in science, ready to tackle higher-level medical science courses. While admissions requirements are evolving, premedical students will face increased uncertainty, but as the standards and rigor increase, their courses will become more relevant and compelling. The competencies evaluated by the Medical College Admissions Test, in turn, will have to be revised. I believe that for students and teachers alike, the positive effects of these changes far outweigh the negatives. Those who teach undergraduates should not shy away from the challenge. Medical schools should stimulate colleges to innovate, and premedical students should demand science courses that prepare them directly and efficiently for the advanced study of biology. Premedical science should never have become a "trial by fire."

In recent years, calls have come from various quarters for medical schools to require and for colleges to teach ethics, altruism, compassion, listening skills, and skills relevant to health policy and economics — at the expense of science requirements. In my view, these aspects of medicine are best reserved for medical schools, where they can be taught in the meaningful context of interactions with patients. Medical educators take seriously their responsibility to equip students for the practice of scientifically anchored medicine. If medical schools are to have the freedom to fulfill that responsibility, students should arrive with a higher level of scientific competence, and colleges can contribute by preparing students more efficiently for the study of contemporary, sophisticated, biologically relevant science.

No potential conflict of interest relevant to this article was reported.

Dr. Dienstag is the dean for medical education at Harvard Medical School, Boston.

BECOMING A PHYSICIAN

From All Walks of Life — Nontraditional Medical Students and the Future of Medicine

Sandeep Jauhar, M.D., Ph.D.

When I was growing up, my parents wanted me to become a doctor, but I had other ideas. I wanted to be a television journalist, or perhaps a trial lawyer or private investigator — something with panache. In college, intoxicated by the mysteries of the universe, I ended up studying condensed-matter physics, in which I eventually earned a Ph.D. But after a close friend contracted an incurable illness, I began to have doubts about my career path. Seeking a profession of tangible purpose — like many older students — I was drawn to medicine.

When I entered medical school at 26, I was considered to be a nontraditional student — but I was hardly alone. A middle-aged woman in my class had an advanced degree in cell biology. One classmate in his early 30s had been a physician assistant for 10 years; there were also a lawyer and an AmeriCorps organizer among us. We were the new face of medicine, or so we were told, and there was considerable interest in us from professors and administrators, if not from our classmates.

The mean age of first-year medical students today is about 24, though 10% are 27 or older. Medical schools now routinely admit students in their 30s or 40s who already have families or are well into another career before turning toward medicine. In general, these students have been welcomed into the profession. They bring maturity, diversity, broader perspectives, "life experience." But what do these physicists, musicians, actors, lawyers, writers, stockbrokers, and dancers add to the profession? Since primary care physicians are in short supply, doesn't medicine just need more conventional, nose-to-the-grindstone clinicians?

Of course, nowadays, when many medical school applicants boast myriad resumé-building experiences, it isn't always clear what "nontraditional" means. Quirky undergraduate concentrations such as music or film are popular among applicants, and so are dual degrees. Female sex ceased to be a distinguishing characteristic years ago. "'Nontraditional' these days is quite a bit different from what it was back when I was in medical school," notes Scott Barnett, associate dean for admissions and graduate medical education at New York's Mount Sinai School of Medicine. "At our school, 50% of medical students are non-science majors. Out of 140 students, a quarter are from our [undergraduate] Humanities in