Genetics, Epidemiology, and Ethics: Organizing Principles for Medical Education in the 21st Century

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The field of medical genetics is providing new information that is rapidly changing the way medicine is practiced. Mapping of the human genome, which is about half-way complete and expected to be concluded by 2003,[1] has staggering implications for health care. Traditional intervention-based strategies likely will be replaced by prevention- and wellness-based strategies as the new medical genetics enables physicians to predict who is at risk for disease and to advise patients about disease prevention. Also, physicians will be expected to integrate information about the relationship between patients' genetic risk for disease and their environments, and they must effectively consider the many ethical implications that this new medical knowledge presents.

Recognizing the dramatic changes underway in the practice of medicine, a faculty-led task force at The University of Vermont's College of Medicine (UVM) has proposed an innovative curriculum that will assure that future physicians successfully integrate genetics, epidemiology, and ethics into their practices. These three disciplines will serve as organizing principles for a curriculum that is competency-based, patient-focused, and integrated across the basic and clinical sciences. The combination of these features will mean that Vermont's curriculum will be unique among medical schools.

In this chapter, I will argue that medical education reform must integrate the new genetics with medicine and that it must be taught in the context of epidemiology and ethics. I will describe the educational reform process (still underway) at The University of Vermont and detail elements of the proposed curriculum. Although medical education reform is certain at UVM, it is important to note that details of this proposal still will be debated by the College of Medicine faculty, and changes are likely before the new curriculum is implemented in the next few years.

Curriculum Reform at Vermont's College of Medicine

Founded in 1822, UVM's College of Medicine is the fifth oldest medical school in the U.S. The College's last major curriculum reform 25 years ago was revolutionary in its efforts (including introducing medical students to clinical care in their first year) to integrate basic and clinical science education. This curriculum is highly valued by faculty and students. Evidence of UVM's excellence includes high rankings in the American Association of Medical College's annual questionnaire of student attitudes, the annual application by more than 6,000 prospective students for 93 positions, and internationally recognized medical research programs. With these successful indicators, there had been little reason to change the curriculum.

Knowing, however, that the College of Medicine faced inevitable pressures from the changing world of medical knowledge and practice, Dean John W. Frymoyer, M.D. and Executive Dean John N. Evans, Ph.D. charged a group of faculty in November 1996 to examine the strengths and weaknesses of the current curriculum and to develop guidelines for reform.[2] The charge to the curriculum task force was to develop a dynamic curriculum that would meet the needs of medical students and the health care profession into the 21st century and to design a curriculum that was competency-based, wellness-focused, and founded in the science of learning.

After considering various alternatives, the task force (which included faculty, residents, and students) presented its recommendation to the deans in June 1998.[3] The group proposed a major curriculum reform based on a theoretical framework that integrates genetics, epidemiology, and ethics as the fundamental focus for the learning and practice of medicine. The task force argued that a genetics-based framework would shift attention from a disease-based intervention model to a health-based prevention model of health care. Several innovative components are integral to the proposed Vermont Integrated Curriculum: further integration of basic and clinical sciences; the incorporation of humanism, ethics, and systems (probabilistic) thinking into the curriculum; and reliance on advanced information technologies.

In making its recommendations, the Vermont curriculum task force drew on the expertise of the American Society of Human Genetics, which argued in 1995 that medical genetics is one of the most

rapidly advancing fields of medicine; molecular genetics is now integral to all aspects of biomedical science. Every physician who practices in the 21st century will require a basic knowledge of the principles of human genetics and their application to a wide variety of clinical problems.[4] Francis Collins recently stated that medical advances linked to the mapping of the human genome will radically change the health care process.[5] Medicine must accommodate new genetic tests that will assist in predicting disease risk, in choosing correct medications (pharmacogenetics), and in discovering new therapeutics. Each medical school must find the best way to incorporate teaching in medical genetics into its own curriculum."[6] Although many advances in genetic mapping, sequencing, association, and linkage studies have made their way into medical education, genetics has not yet been fully integrated into medical curricula.[7]

Why Include Genetic Epidemiology and Ethics in the Reform?

The interplay between environmental agents and genetic factors is important to every facet of human health and disease.[8] The study of this interplay is the science of genetic epidemiology. A curriculum that combines the study of genetics and epidemiology will allow us to study disease variability by age, gender, socio-economic status, and ethnicity. The science of genetic epidemiology will help to demystify and debunk damaging misconceptions about disease distributions in minority, gender, and ethnic groups by relating humans at a genetic and environmental level rather than a superficial phenotypic level. The new medical genetics will use better-informed phenotypes that include the understanding of the susceptibility to disease in concert with the environmental and behavioral factors that exacerbate the susceptibility of developing the disease.

Once the decision to combine genetics and epidemiology was made, it was impossible to resist including ethics in our reform. The study of the variability of genetic makeup (genetics) and the distribution of genes in environments (epidemiology) creates incredible ethical dilemmas that will challenge both society and medicine.[9] The implications of practicing medicine in an environment in which one's genetic and environmental make-ups play a role in virtually all diseases place a huge burden on the physician to consider the ethical implications of advice, diagnoses, and treatment recommendations. Ethical considerations begin with the issue of wellness (i.e., pre-symptomatic genetic testing) and include

issues of reproduction and prevention.

Although teaching genetics, epidemiology, or ethics is not new, Vermont's proposal is unique in that we will integrate these three comprehensive disciplines and place them at the core of the curriculum. While medical school curricula that include only one of the three disciplines have met with only measured success, we believe that integrating them, placing them at the core of all medical education, and assuring that students achieve competence in each will result in providing future physicians with the knowledge, skills, and attitudes that will be required of them in the 21st century.

Designing Vermont's Integrated Curriculum Around Genetics, Epidemiology, and Ethics

UVM's task force recommended that the new curriculum be based on several key principles. First, we agreed that an expert understanding of genetics, epidemiology, and ethics (GEE) is fundamental to the future practice of medicine. Second, we concluded that the proposed curriculum must recognize that the sheer mass of basic and clinical science information makes it impossible to have an educational philosophy based on "knowing all of the relevant facts." The task force acknowledged that a new curriculum must respond to the rapid growth in medical knowledge and the limited amount of time that students have to learn this knowledge. Third, we resolved to integrate basic and clinical science teaching more fully than we currently do. Finally, we concluded that the best way to advance our goal of content integration is through information technology applications. An aggressive investment in computer technology will allow us to develop databases that can be used to develop online teaching software, online assessment software, and databases to track student mastery. Effective use of information solutions will facilitate the faculty's ability to teach and evaluate all of the UVM competencies[10] and improve the likelihood that students will learn and master the knowledge, skills, and attitudes needed to be effective physicians in the years to come.

Curriculum principles: The proposal for incorporating genetics, epidemiology, and ethics into the curriculum follows the American Society of Human Genetics recommendations concerning medical school curricula[11] with two modifications: we included epidemiology and ethics along with genetics, and we added a fifth curriculum principle regarding faculty training.

ASHG recommendation #1: Medical genetics is both a basic biomedical science and a clinical specialty; it is insufficient to teach it as either alone. *Vermont's proposal*: In the Vermont Integrated Curriculum, we have proposed the further integration of basic and clinical science teaching. Genetics, epidemiology, and ethics will be included in this integration approach, which we will accomplish through the use of faculty tutorials and information technology solutions.

ASHG recommendation #2: Medical genetics must be explicitly included in the curriculum. Although some aspects of medical genetics overlap with, and may be taught by, other disciplines, students are unlikely to learn what they need unless specific learning objectives in medical genetics are established for them. *Vermont's proposal*: In the Vermont Integrated Curriculum, we will accomplish this goal through the use of established GEE knowledge, skills, and attitudes, which will be taught in the introductory course and then reiterated in clinical and information tutorials.

ASHG recommendation #3: A person or committee should be given specific responsibility for the curriculum in medical genetics at each medical school. This responsibility should extend throughout the entire curriculum and should include involvement in all courses that contain (or should contain) material related to medical genetics. *Vermont's proposal*: The College's Associate Dean for Medical Education already has assembled a committee for the genetics curriculum and has asked that the group design an approach for integrating genetics into the curriculum. The committee also will design and implement the genetics, epidemiology, and ethics curriculum. The committee likely will work with course directors from the other disciplines to appropriately integrate GEE across the four years of undergraduate medical education.

ASHG recommendation #4: Medical genetics can be taught effectively by a variety of different methods and in various formats. Problem-based learning is particularly well-suited to medical genetics, which involves the integration of skills and knowledge from many different fields. *Vermont's proposal*: The curriculum design team is considering the methods and formats for teaching at our medical school. We have recommended a competency based approach that begins with an introductory course, progresses through small group tutorials, is supplemented by information solutions learning (self-paced, learner focused, and integrated online instruction), and culminates with a scholarly project. Students will be

assessed and evaluated at each step.

Vermont's principle #5: Although ASHG does not address the issue of faculty development, UVM's curriculum task force believes that implementing genetics at the core of the curriculum will be successful only if the process includes an aggressive faculty development program. We do not have on the faculty now the necessary number of medical geneticists, epidemiologists, and ethicists to teach and tutor as the curriculum proposes, nor have our faculty fully mastered the knowledge, skills, and attitudes required by GEE. Prior to teaching the knowledge, skills, and attitudes of the GEE to students, it will be necessary to help our faculty master these concepts. The goal of the faculty development program is to prepare a group of faculty members to become tutors and instructors in the GEE approach. The Vermont Integrated Curriculum proposal devotes a full year to faculty development before the curriculum is implemented for students.

Competency-based curriculum: Vermont has embraced a competency-based curriculum that requires that outcomes of instruction be observable and measurable. The competencies of a curriculum reflect the intent and values of the school in descriptions of knowledge, skills, and attitudes of its professional graduates.

Under the direction of Associate Dean for Medical Education Diane Magrane, M.D., the faculty completed a competency-based exercise in 1996 by identifying the core knowledge, skills, and attitudes expected of UVM's College of Medicine graduates. Although the resultant *Competencies for the M.D. Degree*[12] remains a work in progress, it delineates key competencies that our students must master prior to graduation. To fulfill our dual goals of organizing the curriculum around GEE and having it be competency-based, we adopted ASHG's recommendations for knowledge, skills, and attitudes for genetics[13] and included them, along with Vermont Integrated Curriculum competencies, in a computerized database.[14] Information technologies, then, provide not only a means of educating students but also a means of tracking their educational progress by following their mastery of specific knowledge facts and demonstrating mastery of specific skills and attitudes.

Following are brief examples of GEE competencies; Appendix A has additional examples. (For a full listing of the UVM competencies, please see *Competencies for the M.D. Degree*.[15] For a full listing of the ASHG knowledge, skills, and attitudes requirements, please

see the Report from the American Society of Human Genetics Information and Education Committee.[16])

Sample **knowledge** competencies include having students know:

— what genes are, how they are organized and controlled, what they do, and how they segregate,

— the nature of mutations and premutations and how they contribute to human variability and to diseases,

— the existence of and justification for screening programs to prevent genetic diseases, and

— how novel scientific discoveries can be evaluated in a clinical context and can be applied appropriately to the care of patients.

Sample **skills** competencies include knowing how to:

— elicit a comprehensive medical genetic history and construct an appropriate pedigree,

— formulate an appropriate differential diagnosis and course of investigation, including the use of specialized tests through cytogenetic and molecular genetic laboratories,

— coordinate information from multiple sources into a coherent and rational plan of management, and

— make appropriate referrals for additional diagnostic and therapeutic management, including specialty consultation for clarification and treatment, support from social and community resources, and involvement of allied health professionals.

Sample **attitudes** competencies include having students demonstrate:

— personal qualities of reliability, dependability, and honesty,

— appreciation for the importance of disease prediction and prevention,

— awareness of both the importance of confidentiality and the difficulties that confidentiality poses when relatives are found to be at risk for a serious and potentially preventable disease, and

— respect for patients' religious, moral, and ethic beliefs and biases, even if they differ from students' own beliefs.

Faculty Development and Course Design: Before implementing the GEE curriculum for students, we propose an intensive one-year faculty development program to train all faculty in the competency-based approach to medical education and to increase their mastery of genetics, epidemiology, and ethics. This program will assure that all faculty consider GEE as organizing principles in their teaching, and it will provide a forum for faculty to undertake course design for the new curriculum.

Following the first ASHG principle, a committee charged with the integration and implementation of the GEE principles will be responsible for seeing that they are integrated throughout all four years of the curriculum. Thought leaders, either from within the College of Medicine or from outside centers of excellence, will help design the integrated GEE faculty development course, which will be co-taught by the human medical genetics team, epidemiology experts, and medical ethicists.

The faculty development program will lead to the creation of educational modules that link a number of diseases. Specific clinical examples will be used to create a library of GEE-disorder teaching tutorials for use in the Vermont Integrated Curriculum. Included will be discussions on common disorders such as hypertension, depression, diabetes, and attention deficit hyperactivity disorder in order to debunk misconceptions about the role of genetics and environment in common illness. Because the GEE curriculum must balance the basic and clinical sciences, every faculty member will participate in mixed small-group learning experiences in which they apply the introductory lessons of the GEE curriculum to specific diseases. By training faculty in the importance of GEE, we will have begun the process of integrating those principles into each of the basic and clinical science disciplines.

Faculty also will incorporate the general principles of ethics into the teaching of genetics and epidemiology. The College's lead educational ethicist will help them integrate such principles as respect for autonomy, beneficence and nonmalfeasance, privacy and confidentiality, and justice and equity into lessons on medical genetics. The reference textbook for this course will be *Principles of Medical Genetics* (Gelehrter, Collins, and Ginsburg).[17] Although this text speaks to the issue of epidemiology and ethics, we will add key lessons from other expert genetic epidemiology and ethics sources. In addition to textbooks, we will rely heavily on information tech-

nology to access sites on the World Wide Web such as the human genome project and Ethical, Legal, and Social Issues of the Human Genome Project Web pages.[18]

To assure that faculty development is measurable, we will follow a competency-based approach, developing courses, tutorials, and information solution applications to test their GEE knowledge, skills, and attitudes. Each faculty member who completes this training will exhibit mastery on a number of assessment measures (such as examinations, standardized patients, etc.). The one-year program will effect a grass-roots appreciation of the GEE principles while training 25 to 40 faculty tutors in the new curriculum. Once the faculty development program is complete, we will implement the curriculum for students.

Information technologies to support the curriculum: We propose an expert online information system to assist in teaching students and tracking and evaluating their progress. UVM is constructing a model for an online, filtered set of medical science facts and teaching tools that will educate students through learner-focused teaching. Various modules (some already in development) will assist in teaching GEE knowledge, skills, and attitudes: one will help faculty develop GEE-disorder teaching tutorials; one will help assess student competencies; one will track student progress through the curriculum; another will provide information management; and another will provide access to the Computer-Assisted Teaching System (CATS).

Developed under the direction of William W. Pendlebury, M.D., the CATS program (http://cats.med.uvm.edu/) already has had a significant impact on Vermont's medical school curriculum. CATS will be the model UVM uses to integrate online all of the GEE-disorder tutorials and basic and clinical competencies that will be required of students. The program provides a suite of applications that will allow users to pursue learning in a style that is flexible and individualized.

An example is the proposed Huntington's chorea tutorial. The student will access CATS and type "Huntington's chorea." She will be greeted with a voice-over welcoming her to the Huntington's chorea tutorial, and the computer screen will contain icons for each of the basic and clinical science disciplines. The student may click on any of the icons to access various information specific to

Huntington's. For example, she may:

— launch a video of a patient discussing his Huntington's chorea illness,

— click on the anatomy icon to view brain slices that demonstrate the caudate pathology often seen with this disorder,

— visit the psychiatry module to learn about psychopathology associated with the illness,

— visit learning sites that integrate pharmacology, physical medicine and rehabilitation, and neurology,

— click on the GEE icon for a visual demonstration of the chromosome #4 cytomolecularpathology and a discussion of the genetics of Huntington's chorea. Integrated will be a lesson on Huntington's epidemiology and a discussion on ethical considerations affecting testing and hospice care, or

— follow links to the Human Genome Project and other Web sites that may allow for a more detailed study of the disease.

At all times, CATS will allow the student to proceed with her learning in an individualized way, providing information screened by the College of Medicine faculty. At the end of each tutorial, the student will participate in a prototype teaching/assessment module that challenges the student with questions developed by our faculty and matched to the College's knowledge, skills, and attitudes requirements. Tutorials will provide both immediate and delayed feedback in order to help the student develop problem-solving skills.

Implementing the GEE Curriculum

Vermont's new curriculum will have four key features: a new course to introduce first-year medical students to core GEE concepts, a faculty tutorial program that provides instructors/mentors for students working in small-group problem-solving settings, a culminating scholarly project in which students demonstrate their mastery of integrated GEE concepts, and ongoing assessment of both individual student progress and the relevance of the curriculum to the changing needs of health care.

Introductory Course: Curriculum leaders will design an introductory GEE course that will give medical students in their first semester

a common understanding of the core competencies in genetics, the integral relationship that genetics has with epidemiology and ethics, and the role that the new genetics plays in wellness and prevention. The course will have a small-group, problem-based format that employs both a basic textbook and advanced information technology solutions, which will include GEE-disorder tutorials. Students will be introduced to the faculty tutors who will work with them over the next four years.

We will teach structure of chromosomes and genes, principles of Mendelian inheritance, population and multifactorial inheritance prior to introducing modern molecular genetics. We will then progress through gene organization, regulation, and manipulation before teaching the molecular genetics of human disease.

It is here that we will introduce the lessons of epidemiology (although we will certainly address genetic epidemiology in the population genetics portion of this course). Using Phillippe's definition,[19] we will teach genetic epidemiology as the study of the interaction between genetic and environmental factors in the origin of disease. Basic lessons will include an introduction to fundamental epidemiologic principles and a review of genetic concepts and approaches brought together under the heading of genetic epidemiology. We will review population studies of genetic traits and factors in disease. Basic lessons of familial aggregation of disease by age, gender, geographic location, ethnicity, and socio-economic status will be taught in concert with an appreciation of genetic risk. We will use this information to teach the applications of genetic epidemiology in medicine and public health.

Patients will be the centerpiece of each introductory course lesson. Modules will be disease-based, including such issues as the genetics, epidemiology, and ethics of Down's syndrome, Marfan's syndrome, hemophilia, colon cancer, cystic fibrosis, and breast cancer. For each, students will learn fundamentals of molecular and structural genetics, genetic epidemiology, and ethics. Students will learn not only about the genetopathophysiology of each disorder but also what it means to live with, or have a family member live with, the disease. Different disorders will emphasize different genetic (chromosomal, single gene, oligogenic), epidemiologic, and ethical principles. For instance, with Down's syndrome, we will discuss the importance of cytogenetic testing, maternal age risk, and ethical decisions around common topics such as

prenatal diagnosis and termination. Such discussions will include somatic cell gene replacement therapies, sex selection, and germ cell replacement therapies, all of which are increasingly important issues.

Faculty tutorials: The first principle cited by the American Society of Human Genetics for successful implementation of genetics into medical school curricula was to assure that teaching in medical genetics spans the entire undergraduate medical school curriculum and continues into the post-graduate years as well.[20] After considering the complexities of the clinical education, Vermont's curriculum task force agreed that the best way to implement this principle was through a required four-year tutorial program. Each tutor will complete the faculty development program and then be assigned eight students.

Student groups will include two students from each year of training (during the first three years of the new curriculum, second-, third-, and fourth-year students will participate voluntarily). Tutorial groups will meet for two hours per week for each of the four years. Tutors will be either basic or clinical science faculty, and cross-fertilization among the disciplines will be encouraged.

Over the course of the four years, students will be challenged with increasingly difficult clinical vignettes that are drawn from the GEE-disorder tutorial library and mimic real-world patients. They will be required to solve these vignettes using group problem-solving skills and all available information technology solutions. Students will integrate basic and clinical science information, employ the science of probability and relative risk, and demonstrate ethical and humanistic competencies. The faculty will work with, and evaluate the performance of, the students over the four years. This long-term relationship will be particularly important in helping students to learn ethics and humanism, and it will be critical during biannual faculty assessments of students' skills and attitudes, which are not readily evident from examinations.

Scholarly Project: In order for students to meet the proposed graduation requirements, each must complete a scholarly project that will include (or be based on) GEE concepts. These projects will require students to integrate basic and clinical science facts, address the issue of probability and relative risk in understanding disease

process, and demonstrate mastery of ethical concepts. Students will be judged on their ability to demonstrate advanced skills in integrating complex, multivariable information into a cogent project. Faculty tutors and advanced information systems applications will be available to students as they navigate their way through this requirement.

Assessment/Evaluation: An aggressive assessment/evaluation component is required for any type of curriculum reform to demonstrate the quality of its students, teachers, curriculum, and institution. We propose that the Vermont Integrated Curriculum — including its integrated genetics, epidemiology, and ethics core component — undergo rigorous and ongoing assessment and evaluation. A competency-based curriculum will assure that UVM medical students master the knowledge, skills, and attitudes that will be required of them as physicians. Competencies will be assessed in a variety of ways (using examinations, standardized patients, U.S. Medical Licensing Examination (USMLE) performance, oral interviews, etc.).

Because GEE curriculum competencies already have been identified, the College's assessment team can now develop appropriate methods of evaluation for each. The information systems team will develop technological solutions to help track student competencies, and faculty tutors will be responsible for observing skills and attitudes that are difficult to measure through standard evaluations. UVM's evaluation will be modeled after the USMLE approach, which emphasizes genetics and integration.

Conclusions

Vermont has proposed an approach to teaching medical genetics that meets all the requirements of the American Society of Human Genetics and that includes not only genetics but also epidemiology and ethics, which we believe cannot be separated. We have proposed that three key leaders (one each in genetics, epidemiology, and ethics) be given the responsibility for designing and guiding the integration of GEE in our curriculum. We have assured that GEE will be taught throughout all four years of the undergraduate education through a tutorial program. We have explicitly identified which aspects of medical genetics (and epidemiology and ethics) must be taught by adopting and adapting the knowledge, skills, and attitudes for human medical genetics proposed by the American Society of Human Genetics. We have assured that GEE will be taught using multiple methods, including early introduction of those

principals, small group problem-solving exercises throughout the four years, a culminating scholarly project, and effective use of information technology. We have added two features not proposed by the ASHG that we believe will increase the likelihood of success of the curriculum: an intensive faculty development program to imbue the faculty with GEE concepts before we institute curricular reform, and an aggressive assessment and evaluation program that will measure how effectively the Vermont Integrated Curriculum incorporates genetics, epidemiology, and ethics into medical education.

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DISCUSSION HIGHLIGHTS:

— The Vermont experience will need careful assessment, but there are two approaches to assessment. The first decides what should be taught, teaches it and then measures the mastery of the knowledge that was taught. The other, and the more modern, uses assessment as a tool to drive the curriculum by dictating what students need to know.

— One strategy for increasing overall exposure to genetics in medical school curricula would be to increase the emphasis given to genetics on National Board examinations but a number of barriers exist. In practice, because of security concerns, few people actually know what is on the exam, and that includes genetic content. Most faculty members rely on what students who have taken the exam remember as their guide to content. That is not a reliable indicator because students tend to remember those areas where they felt they did poorly, not the entire exam. Too many constituencies, not just genetics, are pressing for greater emphasis on the exam. That leads those who draw up the exam to grapple with the very practical question of what should be eliminated to make room for new subjects. Another problem is that the exam needs to test on materials taught in all medical schools, not just a few.

— The Vermont program has changed its definition of medical education to begin with the first day of medical school and to continue until the end of practice. The competencies, knowledge, skills and attitudes to be taught have been identified by the faculty. Information technology will be used to measure competencies as students move through medical school and, eventually, after they graduate.

— The Vermont program was designed during the course of several years, with input from other colleges, from patients, from students, and from faculty, but always with the support of both the Dean and the President of the University. In many ways, Vermont provides an ideal setting to try such dramatic change, for the school is small, with only 400 full time and 1,000 clinical faculty members. Faculty leaders have been selected for their dedication to teaching. They are being taught the competency-based approach and their competencies will then be assessed. Vermont has also made a determined effort to recruit new faculty leaders

who exemplify what the school is trying to achieve. The new chair of pediatrics, for instance, is known for his commitment to patient-focused education rather than to research.

— Students who have been involved with the new curriculum design wish they could have it, or come back with a guarantee they can tap into the system as it unfolds. But, while students today are more advanced in information technology than they have been in the past, it is not clear whether different teaching will attract different students. Some students do better with a lecture based curriculum, others with a problem-based, self-driven learning situation. They are not the same students. It is important that prospective students understand the changes taking place at Vermont so that those who seek a more conventional education can attend a different school.

— The experience of the medical school at the University of Maryland demonstrates that curriculum change can be accomplished quickly. Six years ago, when the school decided to revise a curriculum it considered outdated, faculty spent a year considering proposed changes, with input from the community, from other medical schools and from other schools at the University of Maryland. A year later, the school offered a new curriculum, with a stronger emphasis on genetics and epidemiology. Faculty response has been positive, reinforced by a program to improve the teaching skills of the faculty member.

— The changes in the Vermont curriculum related to genetics raise a number of important questions. Will a genetic perspective and competency-based curricula attract different kinds of people to medicine? How will those people be identified? What do undergraduate universities need to know about how they should prepare students? How can the MCAT provide a better measure of what students are ready to learn?