Balancing Traditional Values in Academic Medicine with Advances in Science and Technology

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Scientific discovery, population growth, and world commerce are converging to reshape medicine in unforeseen ways. Instead of responding passively to change we must embrace each challenge as an opportunity. Critical issues facing academic medicine today include a revolution in molecular biology and biotechnology, spiraling costs of health care, lack of consensus on a frame of reference for strategic planning (global versus local), and lack of appropriate methods of assessment (outcome analysis). These issues are complex and broad. Thus, it may be that the best that can emerge from our discussion is to identify the major dimensions along which progress may be expected and to predict ways in which change can be directed to serve the needs of health care institutions and medical professionals around the world. Solutions will require innovation in medical education, leadership, and international collaboration.

Key words: medical education; United States

"History shows that great economic and social forces flow like a tide over communities, which are only half-conscious of that which is befalling them. Wiser statesmen foresee what the time is thus bringing, and try to shape institutions that mold men's thoughts and purposes in accordance with the change that is silently coming on. The unwise are those who bring nothing constructive to the process and who greatly imperil the future of mankind leaving great questions to be fought out between ignorant change on the one hand and ignorant opposition on the other."

John Stuart Mill

We appreciate this opportunity to reflect on the enormous challenges facing academic medicine and make predictions regarding future trends. We believe that the community of physicians, educators, and scientists should pursue forward-looking visions and actively participate in reinvigorating our profession. Our experiences in academic medicine span two generations (father and son) of service at several health science institutions, including the National Institutes of Health (Bethesda), University of Minnesota Medical School (Minneapolis), and Jefferson Medical College of Thomas Jefferson University (Philadelphia).

The mission of academic medicine is to prepare the next generation of physicians; to push the envelope of scientific knowledge; to provide excellent clinical service to patients; and to provide for continuing education to physicians in practice. Although academic medicine has succeeded in upholding this tradition, new social, political, economic, and scientific forces will make change inevitable (1,2). Where will our students practice? How will new knowledge gained from basic research impact medicine? Who will pay for the increasing costs of drug development and medical practice? How do we address issues of global health care and patient responsibility? Our response to these challenges will hopefully provide an opportunity for academic medicine to improve the quality of teaching, research, and service, and meet the expectations of society.

In this article, we review predictions of change that were made nearly forty years ago, examine some of the dominant forces affecting our profession at the present time (focusing on science and technology), and provide suggestions for managing change through innovations in education.

Historical Perspective

We are reminded that the complexities of change in academic medicine have been contemplated previously. In writing on this subject in the 1960's, Ward Darley (3) spoke of medicine as: "The meeting ground of all the sciences and all the arts. Medicine adds to and takes from all areas of human endeavor ... Medicine is involved with every aspect of human welfare ... It is the concern of all our people, whether they think they need its help or not." He continued (4): "For if societies future expectations in health and medical service are to be satisfied, the ob-
The research and development budget for pharmaceutical companies in the United States is now approaching 40 billion dollars annually. This economic reality will contribute to a growing disparity in health care between developed and developing countries.

Objectives and programs of the physician education must be deliberately based upon the anticipation of change – change for both the academic and practicing professions."

In 1967, Darley listed seven changes (Table 1) that he believed were inevitable in medicine (4). History has shown that all seven predictions were correct. Biomedical knowledge, as gauged by scientific publications, patents, research budgets and drug discoveries, has increased exponentially. Public education, awareness of patient rights, and the advent of the internet have all contributed to an increased demand for health care. There is increased complexity in data processing and communication – far beyond what could have been imagined forty years ago. These lessons of the past tell us that advances in academic medicine and technology can keep pace with change to affect progress in health care delivery.

One of Ward Darley’s predictions that continues to be a major concern is the spiraling cost of health care. Scientific discovery and technology have given the United States a health care system of which we are very proud. However, the enormous costs involved have prompted many to reconsider the role of science and technology in medicine. Is it out of control? In his recent book, *What Price Better Health Care? Hazards of the Research Imperative*, Daniel Callahan argues that spiraling costs will increasingly make health care available only to the few who are able to pay (5). Major pharmaceutical companies today spend about 900 million dollars to develop, test, and obtain approval for each new drug. Due to this enormous financial burden, most pharmaceutical companies focus on drugs that are expected to show a high return on investment (e.g., drugs for treating chronic diseases, such as cardiovascular disease). Lipitor and Zocor are the top-selling drugs in the United States, with combined sales over 11 billion dollars annually. The research and development budget for pharmaceutical companies in the United States is now approaching 40 billion dollars annually. This economic reality will contribute to a growing disparity in health care between developed and developing countries.

### Forces Shaping Academic Medicine

**Science and Technology**

Decoding the human genome (Human Genome Project), coupled with rapid advances in our understanding of the genetic control of human reproduction and development, provide the foundation for a revolution in science. Approximately 30,000 genes determine human form and function, and (seemingly minor) single nucleotide polymorphisms (SNPs) account for essentially all phenotypic differences between individuals. Stem cells derived from early human embryos can be expanded in culture and coaxed to differentiate into normal germline and somatic cells for use in regenerative medicine (e.g., seeding the failing human heart with cardiac myocyte stem cells). Assisted reproduction (*in vitro* fertilization) is now performed successfully at clinics around the world. However, the ability to derive human eggs from aborted fetuses and even from embryonic stem cells in culture raises new ethical questions. Should human reproductive cloning be permitted under certain circumstances or outlawed as an abomination? The laws that regulate access to human gametes and embryonic cells vary widely throughout the world, compounding our ability to conduct basic and clinical research. Physicians need education and guidance in working through these complex scientific and ethical issues.

Biototechnology is moving so rapidly today that major changes in medical practice seem inevitable (6). Today, it is possible to move genes from one species to another, correct mutated genes, add new genes, delete deleterious genes, and modify existing genes. Genes can even be patented. An analysis of single nucleotide polymorphisms by micro-array analysis can provide patients with a wealth of medically-relevant information, including estimates of risk for developing future disease. The legal and ethical questions associated with these innovations in biotechnology (e.g., issues of genetic determinism and patient privacy rights) must be resolved. We believe that this is a major, perhaps a defining, task that is set before academic medicine in the 21st century.

One example of the evolving relationship between science, technology, and medicine concerns the application of gene micro-array analysis to diagnostic pathology. It is now possible to monitor global patterns of gene expression in tumor specimens and make predictions regarding the likelihood of metastasis for individual patients (7). Private biotechnology companies can analyze gene expression profiles in samples of breast cancer and use the data to estimate the potential for malignant spread on a three-point scale (low, intermediate, high). This new diagnostic test is expensive (3,000-4,000 dollars) and can not be provided to all women. Yet, considering the number of women in the United States that are diagnosed with breast cancer every year (>200,000), there is a substantial market for this new diagnostic procedure.

### Globalization/Multiculturalism

Population trends (both domestically and internationally) will alter demands for health care and require the development of new strategies for efficient health care delivery. How will academic medicine respond to these demographic changes? Mid-century projections released recently by the United States Census Bureau indicate that the United States is becoming larger, older, and culturally more diverse (Table 2). It is estimated that one in five Americans will be over the age of 65 by the year 2030. English will become less dominant in the United States with an expected rise in the Hispanic population. The percentage of the world’s population speaking English as...
Whatever the specific template for organization, we believe that academic medicine should promote scientific and health services research, provide innovative education, and demonstrate leadership in assessment of health outcomes. In addition, academic medicine must increasingly take responsibility for social, economic, scientific, and ethical issues. In this connection, it is important to note that the United States is the only developed nation in which medicine and pharmacy are primarily in the free-enterprise marketplace. Academic physicians often have a broader view of the role of medicine in society, but are reluctant to challenge the entrepreneurial philosophy of the practicing community.

**Table 2. Selected United States Census Bureau data**

<table>
<thead>
<tr>
<th>Demographic data</th>
<th>1900</th>
<th>1950</th>
<th>2000</th>
<th>2050 (projected)</th>
</tr>
</thead>
<tbody>
<tr>
<td>US population (x 10⁶)</td>
<td>75</td>
<td>150</td>
<td>275</td>
<td>400</td>
</tr>
<tr>
<td>Median age (years)</td>
<td>23</td>
<td>30</td>
<td>35</td>
<td>38</td>
</tr>
<tr>
<td>White population (%)</td>
<td>88</td>
<td>89</td>
<td>69</td>
<td>50</td>
</tr>
</tbody>
</table>

*Non-Hispanic, white population.

A first language will diminish from 10% at the turn of the last century to about 5% by the year 2050 (8). English may continue to survive as the dominant language of science and medicine, however, increasing specialization and the introduction of scientific jargon will create gaps in communication. We live in a rapidly changing, multicultural world.

**Frame of Reference**

Academic medicine has been effective in devising strategies for cost effective programs of preventive medicine. However, it has been less successful in teaching students to emphasize the restoration of functions that have been impaired by injury, disease, or disengagement (9). The goals of academic medicine must also encompass alternative modes of medical practice and alternative health care team configurations (10). Patients must become more active as collaborators to enhance the quality of their health care. An example of the need for increased patient responsibility concerns the realization that obesity has become a major lifestyle health problem. The United States Center for Disease Control and Prevention (CDC) reported recently that obesity has become the leading cause of preventable death in the United States, resulting in the untimely death of as many as 500,000 Americans per year (11). This is about the same number of deaths as results from cancer. It is also important to recognize that our world continues to be plagued by the terrible ravages of war, ignorance, and poverty.

**Discussion**

**How Should Academic Medicine Look in the 21st Century?**

Academic medicine is not a coherent discipline. It is an admixture of the basic and applied clinical sciences that are essential to the practice of medicine. Clinical physicians sometimes refer to the “town-gown” tensions that exist between academic health science centers and the community of practicing physicians. Medical schools vary greatly in their organization of clinical and basic sciences. At the University of Minnesota, biological sciences are located on the St. Paul campus, whereas clinical departments are located on the Minneapolis campus, about 10 kilometers away. The University of North Dakota uses medical centers of the entire state as its clinical base for teaching, with supportive basic sciences located at the home base in Grand Forks. Both systems work, although integration is desirable.

How Can We Increase the Impact of Academic Medicine on Health Care?

Collaborate. Most scientific and clinical questions are complex and require the collaboration of several disciplines. Note for example the increasingly large number of authors on journal publications. An interesting story of collaboration between academia and the medical community was encountered on a trip to England many years ago. A practice group in rural Scotland was observed to keep patient identification records on “Key Sort Cards”. When the physicians had questions about the most current knowledge and procedures, they would pull the appropriate stack of cards, study the cases, frame questions, and then contact the medical school to request faculty to visit them as consultants, to help ensure that their practice was “state of the art”. This was an uncomfortable role for many medical school faculty, but it had enormous benefits for the clinicians and their patients. Today, records are stored on computer chips, and medical questions, including pathologic images and live surgical procedures, fly at the speed of light along the internet. Educational programs are offered over the internet. Clearly, new technology is helping to improve communication and collaboration in academic medicine.

Decentralize. An important element of collaboration is sharing of resources (decentralization). In Minnesota, the Regional Medical Program and the Area Health Education Center Program were early attempts to forge linkages between academic health science centers and dispersed regional population centers. Some of these programs evolved into the Rural Physicians Associate Program of the University of Minnesota and the Decentralized Clinical Education System of the University of North Dakota Medical School. Another program developed at the University of Minnesota was the Bush Foundation Mid-Career Fellowship Program. It offered educational expense and partial salary replacement for predominantly rural community physicians to participate in an individually designed “mini-residency” of one to six months. These programs were designed to help physicians better balance their clinical skills with the needs of their practice population. These programs were highly beneficial to the urban academic physicians, helping them better understand the health care needs of rural populations.

During the 1970s, many programs in academic medicine were incorporated into a broad coalition of the health sciences. For example, the University of Minnesota established an Academic Vice President for Health Sciences. This role encompassed the over-
sight, budgeting, coordination of resources and facilities to improve the intra-institutional impact of the academic health sciences. Schools of Public Health, Allied Health, Dentistry and Nursing fell within the domain of this arrangement. The Vice President’s staff included a Coordinator for Continuing Education to help stimulate the existing discipline-oriented programs, and to increase cross-discipline collaboration. This coordinator also worked with the University Public Affairs Office to communicate newsworthy stories to various commercial media outlets.

**How Should Academic Medicine Internationally Be Positioned within Medicine and Also in the Wider Intellectual Arena?**

Leaders in academic medicine are generally literate in one or more non-native languages and often have collaborators in other countries. Participation in international conferences, both clinical and scientific, is increasingly common. National Institutes of Health (NIH) sponsorship of research across national boundaries has helped to stimulate international collaboration. Some research projects are more easily conducted in countries with different modes of health care delivery than the United States. Incentives within the academic community for foreign travel and collaborative research with colleagues in other countries will advance the exchange of ideas, techniques, technology, and data. Some private organizations (e.g., Physicians without Borders) have helped to call attention to some of the most compelling needs of rural populations—particularly in developing countries. Pathogens such as Ebola virus, human immunodeficiency virus (HIV), Polio virus, and drug-resistant bacteria require international leadership for coordinated global responses. These emerging diseases provide an excellent opportunity for leadership in academic medicine and a compelling motivation for international collaboration.

Many leaders in academic medicine increase their impact through leadership in professional societies, within disciplines and across disciplines. Impact is increased by service on peer-review panels for grants and publications, as well as editorial positions for professional journals. A few academic physicians and scientists write columns in newspapers and appear regularly on radio programs (e.g., public radio stations). Local and national newspapers often have knowledgeable science writers who collaborate regularly with opinion leaders in academic medicine, to increase public awareness of current and likely developments in the science and clinical potential of medical advances.

**How Can We Increase Recruitment to Academic Medicine?**

Some years ago the Dean of a medical school proposed a theory of communication in academic medicine he called the Ant Hill Theory. A moment’s reflection will distill the essence of this concept. The challenge is to increase the likelihood of chance encounters between colleagues. Some universities have been highly successful in creating environments that foster frequent and casual interaction. In 1892, in speaking to the medical students and faculty of the University of Minnesota, William Osler is quoted as saying (12): “This vitalizing element lies in the men who work in its halls, and in the ideals which they cherish and teach.” His message was that there is a strong personal dimension to leadership and service in academic medicine.

Academicians in the health sciences are usually recruited from internal educational programs. During the later stages of their professional training most individuals are influenced by a special teacher (or project). Such compelling interest and curiosity typically motivates students to pursue deeper involvement in a particular field of study. Thus, the opportunity for talented students to be involved in the research projects of faculty, and to form close personal acquaintances with faculty, would seem to be vital to the successful recruitment of academicians. Mentorship is essential to the goals of reinvigorating academic medicine.

A strong motivating factor for many academics is the opportunity to pursue personal scientific interests, which are not usually commensurate with the rewards of private practice or corporate research. Indeed, one of the long-standing problems in trying to increase recruitment to academic medicine is the disparate reward structure of academic service and medical practice. Careful consideration of these financial realities is essential to retain the most talented new faculty. Excellence in teaching and scholarship can also be encouraged by establishing Clinician Educator tracks for academic promotion. This track is now in place at many medical schools throughout the United States, including The Johns Hopkins University and Thomas Jefferson University. Thomas Jefferson University also maintains a Longitudinal Study Database, which provides an archive of academic and psychosocial data stretching back over 20 years (13). This database is available to health science researchers for testing hypotheses and documenting trends in medical education and patient care. Medical educators have found that this university resource provides a focal point for scholarship in medical education research.

**Conclusion**

Perhaps one of the primary reasons why academic medicine is in need of revitalization is that members of the “team” have no common agreement about exactly what game they are playing, or how they are going to keep score. There seems to be a general lack of incentive to synthesize, integrate, hypothesize, and test ideas. Discussions in medical schools are often devoted to issues that are local and of relatively minor importance, such as curriculum reform. There is no compelling evidence that one type of curriculum or another contributes to the training of better physicians. Students in lecture-based and problem-based curricula demonstrate similar levels of achievement on the United States Medical Licensure Examination (14).

On the other hand, emerging breakthroughs in science and biotechnology are driving medicine in ways that are powerful and unforeseen (e.g., human
cloning and regenerative medicine). The relationship between science and medicine is becoming closer, and yet basic science education and research opportunities are increasingly being driven from the undergraduate medical curriculum because of time constraints and “information overload”. The mantra has become “less is more”. The lack of time for discussion of breakthroughs in biotechnology is compounded by fundamental changes in our approach to teaching. Today, students are handed information that is abstracted, bulleted, and pre-distilled. Lecture notes are prepared in advance of each class (by faculty) and retyped from audio tapes after class (by students). Although popular, a drawback to this approach is that students do not practice active learning skills, including the ability to critically read primary references and synthesize new information.

Systems of education that promote professionalism, humanism, egalitarianism, altruism, independent study, freedom to read, active learning, and research will help bridge gaps and foster new ideas. New topics of pressing social and medical concern should be introduced into the undergraduate medical curriculum (Table 3). Leaders with vision must be acknowledged and rewarded for their time and commitment to their profession, their country, and our world culture.

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Table 3. New topics for undergraduate medical education

| Implications of the human genome map |
| Genetic testing and genetic determinism |
| Science and ethics of gene therapy |
| Ethical issues concerning assisted reproduction |
| Therapeutic and reproductive cloning |
| Stem cell biology and regenerative medicine |
| Enhancing physician empathy |