Biomedical technology, socioeconomics, and biomedical computing: implications for change

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■ Pathology and laboratory medicine have changed rapidly since 1945. Three forces can be recognized as major vectors for change: rapid application of the biotechnology evolving from research in molecular biology, radically changing medical socioeconomics, and the evolving field of medical information science. While these apparently disparate elements affect all of medicine and health care, at the present time they appear to be changing pathology and laboratory medicine to a far greater extent than many other medical specialties. If pathologists fail to make the necessary changes, obsolescence may well overtake the specialty. Planning for the innovative educational and training programs that will be required to meet the future demands of the specialty is essential, not only for those now in practice but for those who will follow us.
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PATHOLOGY and laboratory medicine have changed rapidly since 1945. While such changes were set in motion by national policy decisions made shortly after World War II, they are now largely driven by scientific advances and socioeconomic policies over which pathologists have little or no control, even though they have made major contributions to both.

Pathologists must analyze and understand the forces underlying this new period of change in order to plan rationally for the future, not only for current practice but also for the residency training programs that will produce tomorrow's pathologists. If pathologists fail to engage in such planning, there is a very real danger that the specialty may become irrelevant to the practice of medicine. This paper is presented in the hope that it will make a contribution to the analysis and planning necessary to manage the major changes that are upon the specialty.

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BIOMEDICAL TECHNOLOGY

Advances in biomedical technology have their roots in the post-World War II assumption by the American society and government that medical care was a social

good, and therefore a proper concern for national policy.[2] The early growth in laboratory medicine was spurred by the postwar decision by the federal government to invest in biomedical research and training as an essential first step in improving American health care.

Government concern for the health of the American people stemmed from the unexpectedly high rejection rate, due to physical disability and chronic illness, of young men called for duty in the armed forces during World War II; this massive medical sampling of the general population was perceived to be a measure of the general health of the American people.

During the war the nation mobilized its scientists and scientific resources in a federally funded effort to produce the atomic bomb in a complex and massive effort was led by Vannevar Bush and the scientists on the wartime National Science Council.

Buoyed by the success of the atomic bomb project and winning the War, the Truman Administration felt that this model of programmatic funding focused on science could be used to solve many large societal problems, including improving the health of the nation's population. Fortunately, President Truman had retained his scientific advisory council. Under the direction of Bush, the council elected to attack the concern for the population's health, not through funding for direct medical care, but rather through long-range programs to increase basic biomedical knowledge by funding research and training. Congress adopted the Administration's plan in 1946.

In 1947, the National Institute of Health was chosen as the lead agency for this effort, and from 1950 through 1980 it directed the expansion of biomedical research and personnel training that has made the United States a world leader in medical research and care. One of the results of this effort has been an ever-expanding medical information base and a large cadre of trained physicians who demanded the enhanced diagnostic laboratory support necessary for the scientific practice of medicine.

These new federal research programs focused on the medical schools in the early period from 1950 to 1960, creating the need for large, sophisticated clinical laboratory services, primarily in the large teaching hospitals. The increased funding for basic and clinical research through individual and program-project grants, as well as medical-center facility grants, ensured that academic pathology departments would be the first to use diagnostic laboratories to apply the new biology and its sophisticated technology to patient care.

Pathology departments, and especially their training programs, were profoundly affected by these developments.[3] Before World War II and even into the middle 1940s laboratory medicine could best have been described as a cottage industry. The academic departments were small, and dominated by experimental and anatomic pathologists. This dominance was reinforced by new federal funding that emphasized basic research almost to the exclusion of clinical research. Clinical or hospital pathology was almost entirely represented by surgical pathology, as it had been since the founding of the American Society of Clinical Pathologists in the 1920s, with clinical pathologists in a great minority. Indeed, it was not until 1948 that the American Board of Pathology made clinical pathology a coequal part of the Board examination.[4]

The demand for large numbers of sophisticated tests and for pathologists who were experts in their development and interpretation led to the rapid growth of clinical pathology within many academic departments. This growth was often at the expense of established anatomic divisions, which tended to remain relatively sheltered from the early impact of biomedical research on the practice of laboratory medicine. Many training programs shifted their emphasis to provide experience for their house staff in clinical laboratory disciplines such as blood-banking, clinical chemistry, microbiology, hematology, and immunology.

The philosophical unity of the discipline of pathology, that is, the study of disease mechanism through the observation of changes in form (anatomic pathology) correlated with changes in function (clinical pathology), became frayed by the stress of the remarkable expansion of clinical pathology. Thus developments in laboratory medicine stemming from advances in biomedical research inadvertently drove a wedge between anatomic and clinical pathology, threatening to fragment the essential unity of the discipline during the 1970s and severely disrupting the training programs of many departments.

Due to continuing progress in biomedical research, the application of the techniques of molecular biology to diagnostic pathology has become the challenge of the latter half of the 1980s. The new biotechnology is bringing about a renaissance of anatomic pathology as the center of the clinical laboratory. The application of the new biology to the diagnostic laboratory demands that immunology, microbiology, flow cytometry, recombinant DNA techniques, cytogenetics, DNA probes, and membrane markers all be integrated into the analysis of the tissue specimen if the laboratory is to continue to be at the cutting edge of diagnostic medicine. After several years in which the imbalance between clinical and ana-

tomic pathology threatened disintegration of the discipline, the new biology seems to demand its reintegration. Thus, pathology and pathologists are now presented with a unique opportunity to reunite our specialty, if we seize the opportunity to do so. The training programs are now grappling with this new reality.[3]

SOCIOECONOMIC FACTORS

Until the mid-1950s, the demand for sophisticated laboratory services was confined to the large tertiary-care and teaching centers, in part because patients simply could not afford to pay for such services. However, during the next decade, more and more people were covered by third-party health insurance through the workplace, and by the mid-1960s, generous health-care benefits had become a standard part of industrial wage negotiations. In 1965, the federal government put into effect its own major medical entitlement programs, Medicare and Medicaid. Nearly universal third-party reimbursement for medical services had become a reality, setting the stage for an unprecedented increase in the demand for medical care and, in turn, for laboratory services in all sizes of hospitals. Protected and fully funded by government, industry, and society at large, health care had come to be regarded by society as a right, regardless of cost.[5] Laboratory medicine entered a decade and a half of exponential growth in which economic concerns were almost nonexistent as a moderating influence.[6] Commercialization entered the scene, not only in laboratory medicine, but in all aspects of health care, as entrepreneurs were attracted to this major growth sector of the economy.

The unbridled expansion of laboratory medicine created a whole new set of demands on pathology and pathologists. Training programs expanded dramatically to supply the demand for more clinical pathologists. To meet the increasing workload, pathologists were forced to adopt many of the attributes of business people or managers; they managed large enterprises that employed many people, purchased expensive automated machines, and used data processing systems, among other techniques. As owners or managers of major revenue-generating centers, reimbursement for pathologists escalated almost beyond belief compared to the 1940s and 1950s. Much of the perceived worth of the pathologist was based on the bottom line of the operation, just as with any other businessperson, rather than on expertise as a clinician-scientist and practitioner. In consequence of the new duties, the practicing pathologist lost some identity as a physician, and indeed the pathologist's role in teaching and patient care became diminished in the eyes of other physicians. Academic pathologists were not immune to this economic expansion. The already precarious balance of teaching, service, and research was further upset by changes in revenue that supported the academic departments; in many departments, research and teaching became relatively less important as they became increasingly dependent on patient care revenue for their economic viability and growth. This trend accelerated as research and training grants became more difficult to obtain in the early 1970s.

In the late 1970s, as the national economy began to falter, it became apparent that there were limits to the amount of the Gross National Product that could be allocated to health care and research. Concomitantly, for the first time since World War II, American society began to question the assumption that health care was a social good rather than an economic product.[7] Within an incredibly short time, the expansionary climate of the health care enterprise changed to one of significant deflation and cost containment, even while the public was insisting on the previous high standards of health care.[8] As a consequence of these socioeconomic realities, a cascade of federal legislation soon followed, beginning with TEFRA of 1982, the Diagnostic Related Group (DRG)-based prospective payment system of 1983, the Medicare provision in the Budget Reduction Act of 1984, COBRA of 1985, and most recently OBRA (1986). These Budget Reducation Acts (BRA) all mandated severe constraints in Part A and/or B Medicare funding by Congress. Most forecasters are predicting that, despite all cost containment efforts, the nation's health care outlays will increase from $387 billion in 1984 (11% of the GNP) to $600 billion in 1990.[9] These figures do not suggest any lessening of cost-containment efforts in the near future, but rather that ever more stringent measures to control health care costs will be sought and applied by government, industry, and third-party payers.

These cost-containment measures have seriously affected the manner in which pathologists are being reimbursed. Economic circumstances will dictate that the pathologist will be judged once again on the quality of the teaching, research, and service to the hospital and medical staff, and less on the amount of money the laboratory generates for the institution. Thus, it is imperative that pathologists become highly skilled in applying the new biotechnology to the diagnostic laboratory and that the training programs again produce physician/scientists who will bring new skills and attitudes to their practices. The unique combination of ad-

vances in molecular biology and changes in our socioeconomic milieu presents an opportunity for the pathologist to become a central figure again in medical care.

BIOMEDICAL COMPUTING AND INFORMATION SCIENCE

The major impact of the third and final vector impinging on pathology and laboratory medicine still lies in the future.[10] If one of the major services that a pathologist renders is to provide information and expert consultation to clinical colleagues, and if the viability of pathology as a clinical specialty will increasingly depend on our consultative value to our colleagues, then it is important that we attend to this aspect of our professional environment.

Pathology as a specialty is uniquely situated to take advantage of the application of information science to medical practice. Faced with the overwhelming amount of data being generated by automated analytical instruments, pathologists early in the 1960s turned to computers and automated data processing systems to solve the problem of the capture, transmission, storage, and retrieval of those data. Sophisticated laboratory information systems have evolved from these early efforts, and pathology, more than any other medical specialty, has become comfortable with biomedical computing.

Unfortunately, our ability to generate and transmit enormous amounts of patient data has left the pathologist and the clinician with a staggering information overload and problems in knowledge management. We are overwhelmed by the sheer mass of data generated through our automated systems.

The remarkable decrease in cost and increase in power of computer hardware and software and advances in electronic communications have already made possible programs to produce interpretive reports and integrated data displays and to present information to the clinician.

Since pathologists generate and control such vital data for patient care, they should take the next step and explore the application of the advances in computing and communication technology to develop expert systems to assist in decision-making by the pathologist and the clinician. Research in the techniques of artificial intelligence, such as organizing intelligent laboratory data bases, will greatly enhance the value of the diagnostic laboratory and the effectiveness of the pathologist as a consultant. The application of medical information science to the clinical laboratory will allow better use of our knowledge base to provide optimal care. Clearly research in medical information science should go hand in hand with research and education in molecular biology in both our training programs and continuing education programs of our professional societies. Pathologists should lead medicine into the information age, thus assuring a leadership role in the 1990s and beyond.

SUMMARY

Pathology and pathologists stand at a crossroads today. A period of crisis is upon the specialty, as it faces the enormous changes discussed above. There is a Chinese proverb that states "Crisis is danger and opportunity." The introduction of molecular biology into the clinical laboratory, the radically changing socioeconomic scene, and the advent of robotics and medical information science present pathology with a time of crisis and danger, but also with the opportunity to remake pathology into the queen of the medical disciplines, if only the moment is seized. If pathologists fail to do so, obsolescence may well overtake the specialty.

Change in medicine and in the delivery of health care is everywhere. If pathology is to continue as a viable specialty, planning for the innovative educational and training programs that will be required to meet the future demands of the specialty is essential, not only for those now in practice but for those who will follow us.

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