

A history of pathology and laboratory medicine at Baylor University Medical Center

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By modern standards, the laboratories of a large medical center represent a place for the synthesis and application of the basic sciences to the treatment of patients by engaging in clinical and basic research, performing thousands of procedures daily, and providing discrete teaching programs. These laboratories depend on the institution while the institution and its students, physicians, and patients depend on them.

The laboratories at Baylor University Medical Center (BUMC) have evolved to a fully automated service that uses the latest technology to perform millions of procedures each year for BUMC, hospitals and health centers affiliated with Baylor Health Care System (BHCS), and other hospitals.

EARLY DEVELOPMENT OF PATHOLOGY AND LABORATORY MEDICINE

Pathology has its origins in ancient medicine but developed only as science advanced. Herophilus, one of the great Greek physicians, along with Erasistratus, provided a beginning for anatomical pathology and autopsy (1). They performed the first scientific human cadaveric dissections over a period of 30 to 40 years. Human dissection was then forbidden and not allowed again for over 1800 years.

Events in North Africa and southern Europe, especially at Monte Cassino and Salerno, led to the establishment of the outlines of classical medical education that would prevail for half a millennium. The basic elements of physiological and pathological theory remained the four basic humors and the four qualities; their respective balance was understood to be the objective of health. Humoral imbalance or complexional distemperancy could be diagnosed easily through examination of the urine. Therapeutic procedures followed the Hippocratic triad of regimen, drugs, and surgery, including bloodletting (2).

This humoral theory was disproved during the Enlightenment of the 18th century as hospitals and medical education developed. The study of pathology began to develop rapidly as autopsies were performed more frequently, especially those performed after a patient's illness had been monitored in the hospital. As a result, physicians began to believe that pathology could inform diagnosis. During this period, Auenbrugger (1722–1809) developed a method of auscultation (thumping the chest and noting the resulting sound) by working on cadavers and then on patients (2).

In the 19th century, cell theory advanced. Theodore Schwann (1810–1882) discovered cells in all human tissue. In the mid

1850s, Rudolph Virchow (1821–1902) developed the concept of cellular pathology: a diagnosis of disease could be made by examining cells (2).

Advances in scientific knowledge impacted both medical practice and medical education in Europe and America. The acceptance of anatomy as the basis of disease led to the study of anatomy, both theoretical and practical, “as the cornerstone of all medical teaching” (3).

During the first half of the 19th century, the study of anatomy in the USA suffered because of a “dearth of hospitals and teaching clinics, the lack of full-time teachers, and especially the absence of centralized control over what was taught and who could practice medicine” (3). Pathological anatomy was not taught as an independent subject but was often combined with medicine or perhaps anatomy.

Much-needed reforms in medical education were made in the USA in decades after the Civil War. Harvard University made reforms in 1871, emphasizing “learning by doing.” These reforms were followed by reforms at the University of Pennsylvania and the University of Michigan. The most spectacular innovation in the history of American medical education, however, was the opening of the Johns Hopkins Medical School, which provided 2 years of instruction in the basic sciences and mandatory laboratory work (4).

As advances were being made in Europe and in American cities where medical schools were developing on a scientific basis, fundamental notions of pathology changed more slowly in most of the country:

Older ideas about the nature of disease remained indispensable. To most physicians at mid-century, one disease could still shade into another; illness was still in many ways a place along the spectrum of physiological possibilities—not some categorical entity capable of afflicting almost anyone with the same patterned symptoms, as the most devoted advocates of French medicine contended. Holistic definitions of sickness as a general state of the organism

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were consistent with social attitudes toward need and dependence, in that both included moral as well as material elements. In both, the interplay of individual and environment could well bring about health or disease, prosperity or poverty. At mid-century, every aspect of the relationship between medical knowledge and the hospital was uncertain and subject to future negotiation (5).

The development of scientifically based pathology and clinical laboratory services in the late 19th and early 20th centuries led to the development of effective diagnosis and treatment of patients. These advances inspired those who helped establish a medical school and a modern teaching hospital in Dallas in the earliest years of the 20th century. It was their hope that advances in science, medical education, and medical practice could be made available to the people of Dallas and North Texas.

DEVELOPMENT OF PATHOLOGY AND LABORATORY SERVICES IN THE USA

The early development of pathology and laboratory services in the USA drew heavily on scientific advances and practices in medical schools and their teaching hospitals. The work of medical faculties in Germany and Vienna were particularly influential. These developments—coupled with rapid advances in surgery made possible by anesthetics and the growing acceptance of hospitals as centers of care—influenced medical practice and the provision of services by hospitals in the USA.

Hospital utilization was particularly stimulated by the development of clinical pathology and the introduction of clinical laboratory procedures, according to Dr. George Rosen in his classic study *The Structure of American Medical Practice: 1875-1941* (6). In the late 1870s in New York City, William H. Welch, T. Mitchell Prudden, and their students were the first in the USA to apply clinical pathology to medical diagnosis. Most hospitals had no laboratories (7). In the 1880s when William Osler was clinical professor at the University of Pennsylvania Hospital, he had the hospital's only microscope and the state's only blood-counting apparatus (8). Even though bacteriological methods were available to aid diagnosis, they were not well understood or used by physicians.

However, change was occurring. In 1887, George Dock used funds from William Osler and John Musser to establish a laboratory at the University Hospital in Philadelphia. Later, at the University Hospital at Ann Arbor, he began giving all patients routine laboratory examinations, including urine and blood tests. Often, stomach contents, stools, sputa, vomitus, exudates, and fluids obtained by puncture were also examined (7). Similar developments were taking place at hospitals throughout the USA (6).

In Texas generally and in Dallas specifically, developments in pathology and laboratory medicine paralleled those in eastern and midwestern states, although developments in Texas took place later and more slowly.

PATHOLOGY AND LABORATORY SERVICES AT THE TEXAS BAPTIST MEMORIAL SANITARIUM: 1903–1920

The Texas Baptist Memorial Sanitarium opened at the end of 1903 in a converted residence that had been operated briefly by Dr. Charles M. Rosser as the Good Samaritan Hospital. The facility almost immediately proved unsatisfactory for patient



Figure 1. Interns in an early laboratory at the Baylor College of Medicine in Dallas.

care and teaching purposes and was closed until a new hospital could be constructed on an adjacent site. The new Texas Baptist Memorial Sanitarium was opened in October 1909 both to serve patients and to be the teaching hospital of Baylor University College of Medicine.

Dr. Abraham Flexner visited the new hospital in November 1909 in conjunction with the national study of medical education he had been commissioned to conduct on behalf of the Carnegie Foundation for the Advancement of Teaching. The sanitarium and especially its laboratories were found wanting. In the Flexner Report, which profoundly influenced medical education in America, it was reported that Baylor University College of Medicine had a good dissecting room, a fair chemical laboratory, and a meagerly equipped laboratory for pathology and bacteriology (Figure 1). In addition, it was not certain there would be funds to maintain those laboratories. Flexner also reported that the college had a "hospital of some 200 beds, in which the school has access to two free wards containing 32 beds, and to an additional negro ward of 22 beds" (9). There was no clinical laboratory.

For many decades, the board, administration, and medical staff of the Texas Baptist Memorial Sanitarium and Baylor University College of Medicine endeavored to provide the facilities, equipment, professional and technical staff, and financing required to ensure the best possible support for quality patient care, professional practice, and, in later decades, clinical and basic sciences research. When they could not do so—as was long the case—the reason was inadequate financing rather than lack of initiative or awareness of what needed to be done. Only in the second half of the 20th century was it financially feasible to bring pathology and laboratory services to the level required by a major medical center.

A summary of the development of laboratories at Baylor Hospital and Baylor University Hospital during the institution's first 3 decades of service was published in 1938 in *Baylor Staff Activities*. According to that authoritative report:

That portion of the laboratory work not done by the interns was performed in Ramseur Hall by Dr. Pierre Wilson, who was in charge of the pathology department of the medical college. The work in Ramseur Hall was continued by Dr. A. E. Thayer from 1910 until 1912 and by Dr. Hitt from 1912 until 1913. . . .



Figure 2. Early leaders in the pathology department: Drs. W. H. Moursund, Janet Caldwell, Stuart Wallace, and Joseph M. Hill.

In 1913, when Dr. W. H. Moursund became professor of pathology and bacteriology, the majority of the laboratory work continued to be done by the interns. Tissue work, bacteriology, and serology were performed in Dr. Moursund's department. The laboratory was located on the second floor of Ramseur Hall beneath the amphitheatre, which extended from the first to the third floor. In 1916, Dr. Marvin Bell, at that time a senior medical student, began doing part-time work in the department. In 1917, at the time of Dr. Moursund's departure, the clinical laboratory work was taken over by Dr. Bell. During these years, great difficulty was encountered in obtaining technicians. For a time during the year 1918, Mrs. Marvin Bell assisted in the performance of laboratory work.

A great impetus was given to the performance of laboratory tests about this time when the American College of Surgeons began to stipulate the laboratory requirements for routine hospital admissions. Dr. George T. Caldwell became professor of pathology in 1919, and the laboratory was removed to the second floor of Ramseur Hall, where it occupied a single room which also served as a pathology museum. Dr. Janet Caldwell assisted Dr. Caldwell in the performance of the duties of the department. During this time, technicians were difficult to obtain and were employed when available. This situation existed in spite of the fact that there were no scholastic prerequisites for technicians, and the period of training was very short. Occasionally it was necessary to employ a technician after a period of training of only a month. One solution of this problem was accomplished by having the hospital urinalyses performed by a medical student prior to his 8:00 classes. Dr. and Mrs. Bell left during the year 1919 (10).

PATHOLOGY AND LABORATORY SERVICES AT BAYLOR HOSPITAL AND BAYLOR UNIVERSITY HOSPITAL: 1920–1950

In 1920, the decision was reached to convert the previously independent Texas Baptist Memorial Sanitarium into a component of Baylor University as part of the Baylor-in-Dallas concept. The hospital's name was changed to Baylor Hospital in 1921 and subsequently to Baylor University Hospital in 1936. *Baylor Staff Activities* continued its discussion of the laboratories during this era:

In 1923, a grant was obtained from the Rockefeller Foundation, of which \$5000 was devoted to the purchase of new equipment for the laboratory.

Dr. Moursund returned in 1921 as professor of clinical pathology and director of the laboratory. When he assumed the duties of dean in 1923, the laboratory was placed under the department of pathology, and Dr. Janet Caldwell became the director. Dr. Ozro T. Woods, at that time a member of the department of pathology, was also interested in the hospital laboratory and instrumental in its development. In 1924, the laboratory was installed for the first time within the hospital building. . . .

Dr. Stuart Wallace took charge of the laboratory in 1927 at the time of the departure of Dr. George T. Caldwell and Dr. Janet Caldwell [Figure 2]. Dr. Wallace remained until 1929 and was



Figure 3. Bernice Miller, a nurse technician, working in the Baylor laboratory in the 1930s.

followed by Dr. Douglas. In 1930, both Dr. Caldwell and Dr. Wallace returned. At this time, the technical departments, previously numbering four, were increased to five, and a fifth technician was added. Dr. Wallace remained director of the laboratory until 1934 and was followed by Dr. Joseph M. Hill. Subsequent rapid increases in volume of laboratory work necessitated a division between the tissue and biochemistry departments and the employment of additional technicians [Figure 3]. In 1935, the requirements for student technicians were increased to 2 years of college work, thus meeting the requirements of the American Society of Clinical Pathologists for an approved School of Laboratory Technique. Subsequently, one student enrolled each month for a 1-year course of study.

In July 1937, the appointment of Dr. Sparkman as resident in pathology marked the opening of this new laboratory service designed to give basic training for preparation for clinical specialties. A required period of training in the laboratory for interns was also inaugurated at this time.

Until February 1936, the only technical services in the dispensary laboratory were those of a technician loaned from the hospital laboratory for a part of the day. In 1936, a full-time technician was employed in the clinic laboratory. At this time, a portion of the dispensary laboratory space was sacrificed for the purpose of providing space for the dispensary x-ray department. In November 1937, a second technician was employed for the dispensary laboratory, and the room was remodeled to provide more space. During these last 2 years, the facilities of this laboratory were greatly expanded so that blood chemistry and bacteriology were available in the clinic in addition to the urinalyses and blood counts that had constituted the work of this department theretofore. The additional help and increased facilities . . . permitted closer supervision and teaching of the clinical clerks.

The growth of the clinical laboratory service . . . [is] best illustrated by a comparison of the number of tests performed per month in 1925, 1928, and [1938]. The records show that in April 1925, 3257 tests were performed; in January 1928, 5186; and in January 1938, 13,296 (10).

During his tenure, Dr. Joseph M. Hill was instrumental in developing the Wadley Institute and Blood Center. Experimental work by Dr. Hill and engineer David Pfeiffer in blood transfusion methods resulted in the design of the Adsorption Temperature Control Vacuum (ADTEVAC) in 1939 to preserve blood plasma by drying it from the frozen state (Figure 4). The Wadley Center became internationally recognized for work on Rh factor problems. By using the ADTEVAC, the Wadley staff developed a method for the large-scale production of serum that could be used

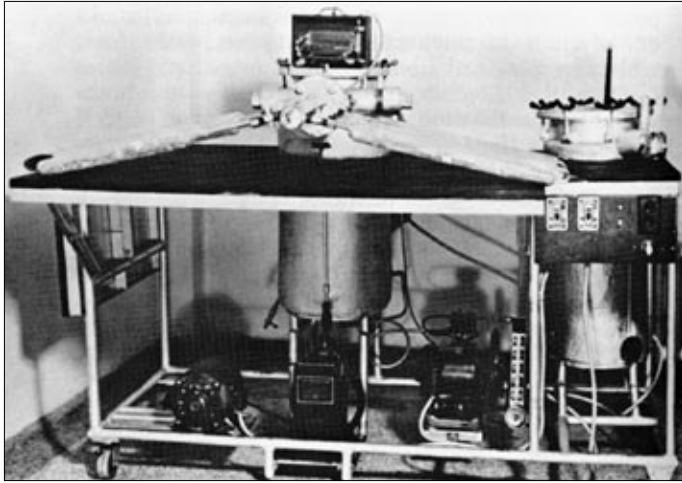


Figure 4. The ADTEVAC machine, which could dry blood plasma, created by Dr. Joseph Hill, head of the Baylor laboratories.



Figure 5. Collecting blood from hundreds of people following the April 1947 Texas City disaster, which killed 500 and injured 3000.

to determine the Rh factor of a person's blood before he or she received a transfusion. This technology was reported in *JAMA* in 1945 and was universally adopted for use.

Baylor University Hospital was the first hospital in the world to have a routine blood typing service. In 1948, Dr. Hill and Dr. Sol Haberman discovered the "little d" blood factor while working with >700 U of blood collected for disaster victims in the Texas City refinery explosion (11, 12) (*Figure 5*).

PATHOLOGY AND LABORATORY SERVICES AT BAYLOR UNIVERSITY HOSPITAL AND BAYLOR UNIVERSITY MEDICAL CENTER: 1950–1980

During the 1950s, Dr. Joseph M. Hill continued to direct both the hospital laboratories and the Wadley Blood Institute. The growing success of the Wadley Blood Institute raised questions of whether it was appropriate for the blood institute, an unrelated legal entity, to continue to operate on the campus of Baylor University Hospital and for Dr. Hill to be responsible for both. Upon the recommendation of Boone Powell, executive director, a special committee of the Baylor University Hospital board was appointed in mid 1958 to consider the future relationship between the hospital and the Wadley Blood Institute. Carr



Figure 6. Dr. George J. Race, chief of pathology from 1959 to 1986.

P. Collins, a senior trustee who had served on the board for nearly 40 years, was appointed chairman of the committee. The medical staff advisory committee, chaired by Dr. J. Warner Duckett, was also invited to present recommendations.

After this intensive, 3-faceted review, it was agreed that Dr. Hill would resign as director of laboratories, a new director who could devote all of his time to overseeing the BUMC laboratories would be selected, and the Wadley Blood Institute's principal activities would

be moved to a location off the campus. Although Dr. Hill resigned as director of laboratories, he continued as a member of the medical staff and served as a research consultant to the hospital. After an extensive search, the medical advisory committee advised the appointment of Dr. George J. Race, and the board gave its approval (*Figure 6*). Dr. Race was a native Texan who had completed his residency at Duke University.

When Dr. George Race came to Baylor in September 1959, <100 people were employed in the laboratories, and most tests had to be performed by hand. There was one trained pathologist, Dr. Fred Preuss; one unlicensed Turkish trainee pathologist; and a backlog of about 200 unfinished autopsies. Clinical chemistry was under the direction of Dr. Robert Speer, a PhD who had worked on the atomic bomb project during World War II. Only about 15 chemistry tests were available when Dr. Speer arrived, and about 450 chemical laboratory procedures were performed at Baylor in a month (12). Jack Porter, a chemist, was employed in 1958 and later was joined by Dr. Joel Young, who worked in the night laboratory and the chemistry laboratory until 1969.

Microbiology was headed by Dr. Sol Haberman, a serologist and bacteriologist (*Figure 7*). Dr. Freida Carson was supervisor of the histology laboratory. John L. Sills, trained in tropical medicine during military service, functioned as the laboratory's chief technologist and coordinator. Mr. Sills consulted with Dr. Joseph Hill and the Wadley Institute staff in addition to working closely with the hematology service and performing urinalysis and parasitology tests. He also worked in the area of supply purchasing for the chemistry and microbiology laboratories and served as a mediator to settle disputes among staff members in these laboratories.

A cryostat was soon obtained, and a hematoxylin and eosin frozen sections service was started. Having worked at Terrell Laboratories in Fort Worth, Dr. Race knew that results from surgical pathology slides could be reported the next day. The existing system provided reports in 3 to 5 days. It was possible to change this to next-day reporting for simple specimens.

The first new staff person recruited by Dr. Race was Dr. Gwendolyn Crass (who had been chief technologist in the Baylor hematology laboratory in 1935 and later became a physician) from the University of Texas Medical Branch at Galveston. Dr. Crass was placed in charge of the hematology laboratory. The next staff member recruited was Dr. Marie Shaw, who was at Memorial Hospital in Lubbock. By January 1, 1960, the staff included 6 pathologists: Drs. Crass, Hill, Preuss, Race, Shaw, and Dr. Alice

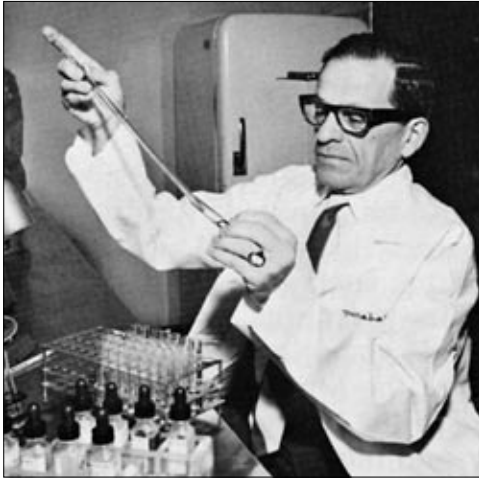


Figure 7. Dr. Sol Haberman, first director of microbiology.

Smith. Next was Dr. William Nickey, who had been a Parkland resident; he came to Dallas 3 months after he completed his military service in the air force.

In May 1960, Pathologists Biomedical Laboratories was formed with the partnership of Drs. Race, Crass, Shaw, and Nickey; its purpose was to provide professional pathology services. Dr. Kingsley joined that partnership when he arrived in 1961; he had been recruited through an advertisement in a national journal. Drs. Nickey and Kingsley were very active in surgical pathology. Dr. Nickey was more involved in the autopsy service. Dr. Kingsley, working closely with Dr. Freida Carson, developed a number of new stains and tests that improved diagnostic procedures in surgical pathology. Later, Dr. Kingsley became director of surgical pathology. He acquired a reputation as a superb diagnostician in tissue pathology.

The professional staff of BUMC's laboratories continued to expand into the 1970s as medical requirements and research opportunities were identified. In part, staff expansion was needed to meet expanding workloads. More importantly, however, staff expansion allowed increasing subspecialization, making it possible for BUMC's laboratories and the professional pathologists' group to provide services in virtually all fields available at other major medical centers, including academic medical centers (Figure 8).

Dr. G. Weldon Tillery, who had been a resident in Baylor's pathology residency training program from 1962 to 1966, joined the staff in 1972. Ten years later, in 1982, Dr. Tillery became assistant laboratory director. In 1986 he succeeded Dr. Race as director of laboratories and continued in that position until 1998.

Dr. Alex W. McCracken joined the staff in microbiology and virology in 1973. Dr. George Moore, a PhD from the University of North Carolina, became director of the urinalysis/parasitology laboratory in 1978 and later became administrative director of the laboratories. Dr. Franklin Sogandares-Bernal, an internationally recognized PhD from Tulane University and the University of Nebraska, served as a consultant in parasitology and immunology. Dr. Joseph Newman, a PhD from the University of Texas Health Science Center in San Antonio, joined the immunology laboratory staff in 1974 and assumed responsibility for the virology laboratory after Dr. McCracken's departure in 1981. Dr. Billy Cooper, a Tulane University PhD from Temple University, established the mycology laboratory when he joined the depart-



Figure 8. Laboratory automation in the 1970s: (a) a Coulter counter to perform complete blood counts; (b) an SMA-6 machine to measure blood levels of sugar, urea nitrogen, sodium, potassium, carbon dioxide, and chloride.

ment in 1975. Dr. Charles Rietz joined the surgical pathology staff in 1975. Dr. Stephan Ritzmann, who trained in Germany and Canada, became director of clinical chemistry and proteinology in 1978 and stayed until his death in 1983.

Development of specialized laboratory services

By 1980, the organization of the department was far different and much more complex than the organizational plan Dr. Race had inherited in 1959, 21 years earlier. Dr. Race was physician-in-chief and director of laboratories. Dr. G. Weldon Tillery was assistant chief of pathology and director of central laboratories; Dr. Norman G. P. Helgeson was director of clinical pathology, division I, clinical pathology laboratories—responsible for the bacteriology, serology, mycology, immunology, parasitology, and special hematology units; Dr. William B. Kingsley was assistant chief of pathology and director of surgical pathology; and Dr. Stephan E. Ritzmann was director of the clinical chemistry laboratory. Others with supervisory responsibilities in 1980 included Dr. Freida L. Carson, as director of the histopathology laboratory; Dr. Billy H. Cooper, as director of mycology; Dr. Alain J. Marengo-Rowe, as director of special hematology; Dr. Alex W. McCracken, as director of clinical microbiology and virology; Dr. George W. Moore, as administrative director of laboratories as well as director of the urinalysis and parasitology laboratory; Dr. Doris D. Vendrell, as director of autopsy service and neuropathology; Dr. Marvin Stone, as head of the immunology branch; Dr. Gwendolyn Crass, as head of the clinical hematology branch;



Figure 9. At the electron microscope: Sunny Bettis and Dr. James H. Martin.

and Dr. Zaven Chakmakjian, as head of the endocrinology service. Glen Clark was the vice president of BUMC with administrative responsibility for the laboratories. Within the plan of organization, there were 84 discrete operating units, each with a designated director or supervisor who was a “working” supervisor, usually the senior professional in the field (13).

Many of the specialized laboratory services had been developed in the 1960s and 1970s, including the electron microscopy laboratory, clinical microbiology laboratory, histopathology laboratory, virology laboratory, endocrinology service, autopsy service, immunology laboratory, special hematology laboratory, blood transfusion service, and nephrology laboratory.

Electron microscopy laboratory. BUMC was very interested in developing an electron microscopy laboratory. Emil Sanders was recruited from the University of Texas Southwestern Medical School, since he knew how to run the EMU3 RCA scope. After Mr. Saunders left in 1962, James H. Martin, an electronics expert, was employed; he was interested in completing graduate studies as well as learning about electron microscopy and supervising the laboratory (Figure 9). Later, Dr. Joseph Lynn, a resident in pathology from Galveston with strong interest in electron microscopy, was added to the staff.

Dr. Freida Carson, working with Mr. Martin and Dr. Lynn, developed a finely buffered formalin used as a dual-purpose fixative that allows both light and electron studies to be made on the same tissue specimen. This inexpensive and simple-to-prepare solution, known as Carson’s fixative, is used in laboratories throughout the world.

Dr. Peter Marcus replaced Dr. Lynn as diagnostic electron microscopist from 1976 through 1981. Both Drs. Carson and Martin attended graduate school while working and ultimately earned doctoral degrees.

Clinical microbiology laboratory. Dr. Norman Helgeson, who had a special interest in microbiology, joined the BUMC medical staff in 1966 from the Massachusetts General Hospital. Dr. David M. Adamson, a PhD, was a member of the microbiology staff from 1969 to 1974 as assistant director of microbiology.

Dr. Helgeson recalled the many major changes and developments that occurred in microbiology during the 3 decades that he headed the microbiology laboratory. These developments included new infections and pathogenic microorganisms; the marked increase in numbers of immunocompromised patients; the increased incidence of hospital-acquired infections; the ability of new technology to advance clinical microbiology; improvements in materials and techniques—such as improved media for culturing fastidious organisms, continuous electronic monitoring of blood cultures, automated identification of yeast isolates, and techniques to speed recovery of fungi from blood culture and viruses from tissue culture—and the transmission of microbiological data to patient records via a computer-based network (14).

Histopathology laboratory. Dr. Freida Carson began working at Baylor in 1956. She said that when she first arrived, pathologists and residents would go to surgery several times each day, making rounds of the operating rooms for specimen collection. Five histotechnicians were employed in the laboratory, and none was certified. Medical technology students also rotated through the histopathology section for 2 months at a time. This rotation was discontinued in 1968. Although the microscopic sections were finished by about 1:00 PM, the cases were not dictated and transcribed until the following morning. Frozen sections were done on the old clinical freezing microtome, using carbon dioxide for freezing the tissue. This technique did not allow freezing of friable tissue such as endometrium or freezing of needle biopsies. Dr. Carson remembered how pleased they were to have one of the early cryostats, which changed the method of using frozen sections for rapid diagnosis.

The laboratory began to change when Dr. Race became director in 1959. Employees had been encouraged to obtain certification as histologic technicians, and in 1971, Baylor became one of the first of 11 hospitals to have an accredited training program. Although the program was discontinued in the 1980s, the emphasis on training and certification continued during Dr. Carson’s 35 years at Baylor.

Instrumentation and methodology were continuously updated so that Baylor could remain one of the premier histopathology laboratories. Before diagnosis-related groups and the emphasis on outpatient surgery, the histopathology laboratory peaked at 18 full-time employees and trainees. The histopathology laboratory became and remains a referral center for diagnostic workups on muscle biopsies, nerve biopsies, kidney biopsies, and unusual immunoperoxidase procedures.

Virology laboratory. A major advance was the establishment of the virology laboratory in 1962. Charles Sammons had given a generous amount of money to assist the radiology department. A proposal to establish a routine virology diagnostic laboratory was developed. At that time, all virology laboratories were research laboratories. BUMC employed Dr. Abbas Bebehani, who was originally from Iran and had a doctorate from the University of Kansas, to head the virology laboratory. When Dr. Bebehani left, Dr. Dighton Rowan was appointed to replace him (Figure 10).

Endocrinology service. One of the first actions taken with regard to chemistry was the establishment of an endocrinology section under Dr. Speer to perform steroid hormone analysis. Later, the endocrinology service was combined with a clinical service, and an entire endocrinology laboratory was established

as a function of the department of pathology. Its director, Dr. Zaven Chakmakjian, who trained at the University of Southern California, also worked in the department of medicine. He was joined by Dr. N. Y. Zachariah, a biochemist PhD from the University of Nebraska.

Autopsy service. Dr. Doris Vendrell joined the staff in 1970 and became director of the autopsy service. Before then, the service was the responsibility of the general pathologists in the department. Dr. Vendrell was very interested in educating residents as well as in improving the autopsy service generally.

The autopsy has long been a major contributor to scientific knowledge as well as a basis for judging physician performance and quality of patient care. In the 1970s, there was high activity in the autopsy service, since most physicians felt the need to have an autopsy to define the disease processes that had led to the demise of patients. Approximately 35% of hospital deaths came to autopsy during the 1970s and, at BUMC, the total number of autopsies performed ranged from 400 to 450 per year.

Beginning in the 1980s, the number of autopsies per year gradually decreased. By the 1990s, the percentage of autopsies had decreased to between 10% and 13%. This decline was not due to a decline in importance of the autopsy. It is likely that newer technologies used in diagnosis provided much information about disease processes before death. These included radiological techniques, needle biopsy techniques, endoscopy, better testing for disease, and tumor markers in the clinical laboratory. While advances in technology accounted for most of the decline, 2 other factors also contributed. One was the reluctance of families to allow autopsies since they were increasingly assured of the cause of death. The other was medical-legal concerns; physicians became more hesitant to pursue autopsies for fear of providing a basis for action by litigious families and plaintiffs' lawyers.

Most autopsies performed at BUMC over the years have been for BUMC patients. A few, however, have been conducted by BUMC pathologists qualified in forensic pathology for public authorities. Most notably, in 1973, the BUMC autopsy laboratory was used by an appointed medical examiner (who was not a BUMC pathologist) to conduct an autopsy of the body of Lee Harvey Oswald, who had been shot and killed in front of television cameras as he was being taken through the basement of the Dallas police station to be transferred to the county jail 2 days after the assassination of President John F. Kennedy.

In 1989, Dr. William G. Herlihy assumed the directorship of the autopsy service after the retirement of Dr. Vendrell. He continued to provide leadership and professional interest in maintaining the autopsy service. He also directed the establishment of standards and policies for making the morgue safer to cope with the wave of infectious diseases of the times, including AIDS and hepatitis, and to give increasingly timely reports to physicians.

Today the autopsy service is under the direction of a full-time, dedicated autopsy pathologist, Dr. Elizabeth Burton. Dr. Burton joined the staff in 2001 after completing a forensics fellowship at Louisiana State University. She is committed to evolving the role of the autopsy to improve patient care at BHCS.

Immunology laboratory. The laboratories included an immunology laboratory, originally established by Dr. J. Lester Matthews, a PhD educated at the University of Illinois. When Dr. Marvin J. Stone, a hematologist/oncologist, came to BUMC from the Uni-



Figure 10. Dr. George Race (left) with Dr. Dighton Rowan, director of virology, and Dr. Floyd Norman, chief of pediatrics, in 1968.

versity of Texas Southwestern Medical School in 1976 to assume the position of director of the Sammons Cancer Center, he was also appointed medical director of the immunology laboratory to take advantage of his expertise and extensive experience in the field of immunology.

Dr. Stone immediately expanded the scope of testing services provided by the laboratory and installed many technological advances. Originally, the laboratory tested for immunoprotein levels and conducted tests for autoimmune disease by electrophoresis, serological techniques, and radiochemical techniques. The laboratory served as a regional reference laboratory in special immunological testing.

In 1986, an ancillary laboratory was created to support the newly developed organ transplant and bone marrow transplant service. The laboratory was designated the transplant immunology laboratory with the primary function of performing tissue typing to match organs with recipients. Without the laboratory, the organ transplant system could not have functioned in the North Texas area. Originally, the testing involved mostly serological techniques. In 1997, however, much of the testing was changed to polymerase chain reactions to improve and expand the scope of tissue typing and organ matching. The newer technology allowed for better, broader-based tissue typing, which improved organ and patient survival.

Special hematology laboratory. With the addition in 1972 of Dr. Alain Marengo-Rowe from Oxford, a special hematology laboratory, blood bank, and coagulation unit were established. Dr. Marengo-Rowe was the initial medical director and continues to oversee this important service. Dr. James Leveson, a PhD from London, was the scientific director. The special hematology laboratory took on rapidly increasing importance in the 1980s and 1990s.

Coagulation testing was the responsibility of Dr. Robert Speer, director of the clinical chemistry laboratory. He established a meticulous, high-quality, routine coagulation service. Advances

in surgery, however, often place demands on the routine service that are difficult to meet, particularly the requirements of heart surgery. Prolonged exposure of a patient's blood to artificial surfaces as well as requirements for massive transfusions cause sudden and dramatic changes in blood chemistry.

Dr. Leveson addressed this problem by using a team approach with regular discussions among surgical team members, nurses, pump technologists, medical laboratory technologists, and hematologists. A databank of patient information has been developed. A working definition of "excessive hemorrhage" was developed, based on studies of chest tube drainage that provided early identification of excessive bleeding monitored with rapid and appropriate laboratory testing. This enabled Dr. Marengo-Rowe to detect any developing coagulopathy and manage it effectively. The concept of component therapy, tailored to the specific abnormalities that occurred in the patient, was introduced.

The special hematology laboratory also provided a battery of tests to compare the baseline results of bleeders and nonbleeders, pioneering the concept that normal values should be based on patients who underwent heart surgery and did not hemorrhage, rather than on "healthy normals." The results were used to narrow the battery of tests to those that could be done quickly and yield maximum information.

The introduction of new tests developed by Dr. Leveson, "the factor deficiency screen," permitted rapid identification of multiple factor defects. These early studies differentiated hematologic parameters that were "abnormal" due to what occurred in all patients who underwent heart surgery from those associated with hemorrhage that occurred in only the 20% of patients experiencing excessive bleeding. For example, platelet aggregation studies (which were new to Dallas) led to significant reduction in the use of platelet transfusions, as all patients undergoing heart surgery had qualitative platelet abnormalities. The rapid and appropriate use of ϵ -aminocaproic acid to quickly curtail a coagulopathy permitted a dramatic reduction in the consumption of blood products. These techniques reduced the appearance of "wet lung syndrome" and dramatically decreased both the use of respirators and the length of stay in an intensive care unit.

As additional operating rooms for heart surgery were opened, an expansion of the program followed since the availability of intensive care unit beds was not a constraint. Within 2 years, the average consumption of blood was reduced from more than 14 U to 2 U per patient, with 30% of the patients requiring no blood or component transfusions throughout their hospital stay.

Increased demand for special hematology services and expansion of coagulation testing led to the amalgamation of coagulation services at BUMC with the special hematology unit in 1979. Special hematology has continued to serve the needs of expanding surgery volume, which by the mid 1980s aggregated 26,000 surgical cases per year, including solid organ transplants. Increased surgical volume was provided for in July 1990 by building a satellite laboratory in the new Roberts Hospital building to supply "stat" testing in hemostasis, hematology, and clinical chemistry. Barbara Roosth funded this important laboratory in memory of her mother, Hilda Roosth.

BUMC's services have subsequently been expanded to include new testing in the diagnosis and therapeutic management of thromboembolic diseases. Developments in hemostasis embrace

a wide range of techniques, including immunologic, coagulative, electrophoretic, and chromogenic technologies. Special hematology has grown from a once small section of just 2 technologists to a staff of 21 experienced technologists (14).

Blood transfusion service. In 1972, the Wadley Blood Bank, which had provided cross-matching and transfusion services for patients at Baylor, moved to a location near Parkland Hospital. Wadley staff members who had performed the transfusion services stayed behind and were housed in BUMC on the third floor of the laboratory building. Personnel included intravenous service nurses and transfusion service technologists, comprising <10 full-time equivalents.

In 1972, approximately 18,000 U of blood and blood components were transfused at Baylor. Most units were given as whole blood. The mix was about 90% whole blood and red cell components and 10% plasma components.

Nephrology laboratory. A nephrology laboratory was introduced in 1978 when Dr. Martin White was appointed director of nephrology for the institution. Dr. White had a specialized testing system for renal function, metabolism, and steroid hormones. The laboratory was small but provided very specialized testing that improved the care of renal patients at BUMC. The laboratory was subsequently absorbed into the core laboratory with emphasis on renal function testing by special radiochemistry techniques.

Surgical pathology for oncology cases

The Sammons Cancer Center, which opened in 1977, had profound effects on the pathology department. As larger numbers of cancer patients were brought into the system, they increased the demand for and the required sophistication of testing. The responsibilities of the laboratories and pathologists grew. Many new tests were provided by the various specialized laboratories in response to the needs of cancer center patients.

Surgical pathology underwent significant changes during this time. There was increasing demand for tissue pathology work, which is essential to the care of cancer patients. More importantly, the cancer center introduced the site-specific tumor conferences to enhance and coordinate patient care, physician education, and training of residents. Pathologists were called upon to take major responsibility in tumor conferences—either by directing conferences or by providing the pathological information and professional evaluations required to conduct the conferences. At one time, there were >22 conferences per month that pathologists were requested to attend. This not only served the needs of the cancer center but also allowed pathologists to develop expertise in various areas of surgical oncology. This was particularly true of the breast tumor conference, head and neck tumor conference, gastrointestinal tumor conference, and skin pathology conference.

Laboratory space

In 1951, the laboratories were relocated from the third floor of Baylor University Hospital, their location since the 1940s, to larger quarters in the Y-wing adjacent to the new Truett Hospital. A brochure summarizing the hospital's activities during 1951–1952 reported that 245,296 laboratory tests were completed, for a daily average of 672. Since that time, the number of tests processed has tended to increase at a rate of about 10% per year.



Figure 11. A pathology resident, Dr. Jackie Torrell, cutting gross tissue in 1979.

The first upgrading of the laboratory space occurred with a remodeling of the third, fourth, and fifth floors of the Y-wing in 1961. The chemistry laboratory was moved to the third floor, the microbiology laboratory was moved to the fourth floor, and the histopathology laboratory and surgical pathology offices were located on the fifth floor.

Training of pathology residents

The pathology residency program at Baylor has been respected for many years (*Figure 11*). The residency was started in 1937 to help fulfill Baylor's effort to provide advanced training for physicians in all significant specialties. It was established not only to provide training for pathologists but also as a way for other subspecialists to get some basic training in pathology during their residencies.

Dr. Robert S. Sparkman was the first pathology resident trained at Baylor University Hospital in 1937–1938. He went on to become a respected general surgeon at BUMC and served as chief of the department of general surgery for many years.

In the early years, there were only a few pathology residents in training at one time. The number in training gradually increased over the years. In 1959, there were 9 residents: 1 American citizen and 8 foreign medical school graduates. Soon there were 12, then 16, and then up to the maximum of 22, including the 2 blood bank residents in 1985. The proportion of the residents who were American medical school graduates increased so that by 1965 >80% were graduates of highly regarded American schools. This increase in numbers, as well as improvement in the qualifications of residents, was primarily due to the efforts of Dr. George Race in his early years at Baylor University Hospital. He was totally dedicated to the expansion and improvement of pathology training. Dr. George Race served as director of the pathology residency training program from the time of his arrival in the department until 1986.

Most former BUMC pathology residents joined group practices at larger voluntary community hospitals such as Presbyterian

Hospital and Methodist Hospital in Dallas and St. Joseph's Hospital in Fort Worth. A few have gone into academic medicine. Former resident Dr. Kamal Ishak, an internationally respected hepatopathologist, is chief of the hepatic and pediatric branch of the Armed Forces Institute of Pathology.

School of medical technology

Baylor's school of medical technology was established in 1934 and continued until July 1996. Directors of the school at various times were Drs. Hill, Race, Crass, and Tillery. School registrars included Marjorie Saunders, John Sills, and Dora Mae Parker.

Approximately 900 medical technologists were trained at Baylor, many becoming employees of the hospital's laboratories. The school was closed, however, when there was a decrease in interest in the profession on the part of young people and, consequently, a decline in applications for admission.

After the BUMC school was closed, medical technologists have been trained at the University of Texas Southwestern Medical Center and at area community colleges. BUMC's pathology department does, however, continue to provide practical, in-laboratory training for the other schools' students under laboratory rotation schedules.

Laboratory Medicine textbook

In 1967, Drs. Joseph Lynn, James Martin, and others presented an exhibit of electron microscopy in surgical pathology at a meeting in Washington, DC. A representative of Harper and Row invited BUMC medical staff members to write a book on electron microscopy. (Drs. J. Lester Matthews and James Martin later coauthored the first atlas of normal human ultrastructure, which was published by Lea and Febiger in 1971.) At the same time, Harper and Row asked Dr. Race and his colleagues to consider preparing a clinical laboratory manual from BUMC training manuals. This was the genesis of a 16-year project to produce and annually revise *Laboratory Medicine*, a 4-volume textbook series containing 6000 to 7000 pages and approximately 1800 illustrations. *Laboratory Medicine* underwent 12 revisions and had more than 100 contributors. The multivolume work was generally regarded as an essential reference source for large- and medium-sized laboratories and was useful at the operational level. Individual parts have been reproduced in other books. In 1985, the final revision of *Laboratory Medicine* was published and has long continued in use across the nation.

PATHOLOGY AND LABORATORY SERVICES AT BUMC: 1980–2003

Between 1980 and 2003, rapid advances and changes were made in pathology and laboratory services. The development of BHCS, with BUMC as its core, expanded responsibilities of the clinical laboratories. As increasing emphasis was placed on clinical integration throughout the health care system, the clinical laboratories and BUMC's pathologists took on new and systemwide responsibilities.

Organization of BUMC laboratories

In 1986, a major change was made in the direction and administration of the BUMC laboratories. A complete restructuring of the laboratories was embarked upon under the direction of Drs. Weldon Tillery (*Figure 12*), Peter Dysert,



Figure 12. Dr. G. Weldon Tillery, chief of pathology from 1986 to 1998.

and Charles Rietz. Many factors guided the process of restructuring. Economic efficiency and functional effectiveness were mandatory for providing laboratory services in times of diminishing resources. As financing of health care changed and Medicare and managed care plans became the principal payers, laboratories lost money rather than serving as the revenue center they had been. Also, it was clear that BHCS needed to become a more integrated and focused system.

The BHCS of the future would be expected to provide services to BUMC, as in the past, and to a growing number of affiliated institutions and clinics in Dallas and North Texas. It was also evident that there would soon be a need for outpatient laboratory services in line with BHCS's new approach to health care delivery.

To meet needs and expectations, plans were made to consolidate laboratory services within BUMC. The laboratories were completely redesigned in keeping with a core laboratory concept. Under this concept, most testing—and that nearly all automated—was consolidated in an area called the core laboratory to be able to achieve consistent-quality, high-output, high-efficiency laboratory testing (Figure 13). The concept provided for concentration of laboratory functions in smaller, more efficient work areas. It also allowed for the absorption of some of the more highly specialized laboratories, which no longer needed to operate as separate or satellite laboratories.

Reorganization was achieved through a series of planned steps: laboratory planning, remodeling of space, realignment and updating of laboratory instrumentation, reassignment and retraining of laboratory staff members, and, finally, the configuration for the core laboratory system.

The BUMC laboratories included a large number of separate laboratory sections before the restructuring, 84 units in all. The 4 major units responsible to the director of laboratories were the core laboratory, microbiology department, immunology department, and special hematology department (Figure 14). Many of the previously existing sections that had been developed over the years—special chemistry, serology, toxicology, urinalysis, endocrinology, and others—were absorbed into major sections.

After the consolidation, only 250 employees were needed to carry the growing laboratory workload compared with the 345 employed before the reorganization. Restructuring also allowed for more effective management of the laboratories by the director of laboratories and



Figure 13. BUMC core laboratory, 2001.

those pathologist-executives responsible for direction of the 4 major elements.

Professional and technical staff expansion

Dr. James J. Aguanno, a PhD from Memphis State University, joined the clinical chemistry staff in 1980. William H. Binnie, DDS, an oral pathologist, was recruited from Guy's Hospital Medical School in London in 1979. Dr. Daniel Savino joined the surgical pathology staff in 1982, Dr. William Herlihy in 1983, and Dr. David Watkins in 1984. Dr. Claudia Greene, a staff member from 1983 to 1989, worked in the area of fine-needle biopsies and cytopathology and helped to establish a service in fine-needle cytology studies of organ allografts.

After arriving in 1982, Dr. Daniel Savino served as a surgical pathologist and took over many specialty areas in the field of renal pathology, immunohistochemistry, breast pathology, and muscle and nerve pathology. In 1988, upon the retirement of Dr. William B. Kingsley, Dr. Savino became director of surgical pathology.

Dr. Peter A. Dysert II assumed responsibility for clinical chemistry in 1984 after completing his residency training at BUMC. He entered upon a distinguished career, during which

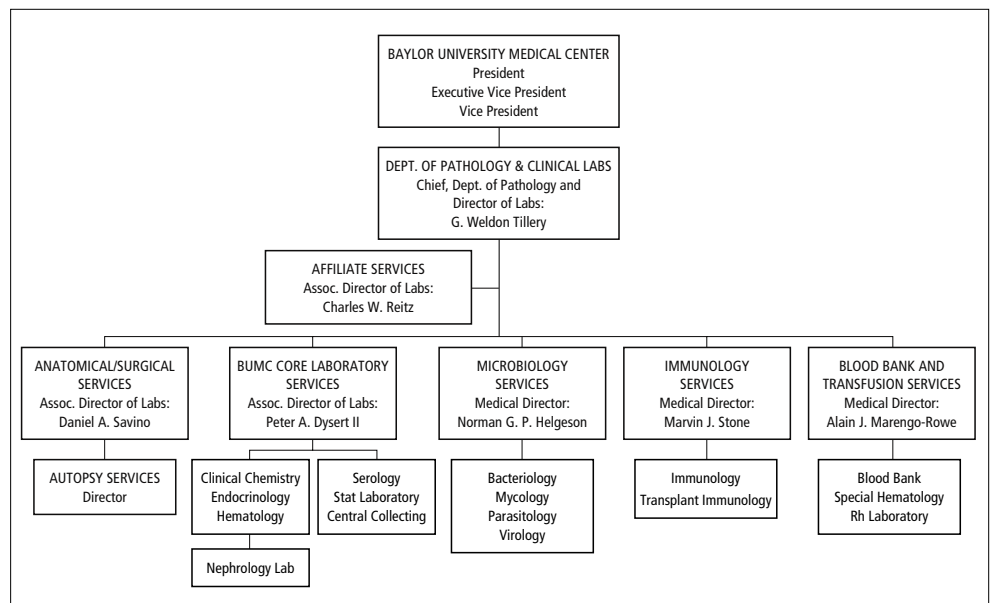


Figure 14. Organization of the BUMC Department of Pathology, 1986.



Figure 15. Dr. Peter A. Dysert II, chief of pathology from 1998 to the present.

he led automation of the BUMC laboratories, headed the core laboratory, led the development of the laboratory information system, served as medical director of BHCS's comprehensive health information system during its development, and became director of laboratories in 1998 (Figure 15), succeeding Dr. Weldon Tillery. Dr. Dysert served as president of BUMC's medical staff in 1998. He was also active in planning for BHCS's participation in the proposed Southwest Health System and in reaching the decision that BHCS

should continue as an independent health system.

Many people in addition to pathologists contributed to the success of Baylor's laboratories. Some of the technologists and technicians who served important supervisory roles and were dedicated to providing quality laboratory procedures include Sunny Bettis, Jerry Bishop, Gabriela Gruschkus, Dorothy Hall, Nancy Larsen, Mildred McCraw, Donna Nicodemus, Dora Mae Parker, Gene Redman, Joan Roberts, Martha Traxler, and George Bridges.

Blood transfusion service

In 1981, BUMC took over the transfusion service from the Wadley Blood Institute. Dr. A. J. Marengo-Rowe was appointed medical director, and Nancy Larsen became supervisor, after having served as supervisor of the intravenous service. Dr. Marengo-Rowe recalled that in 1985, the transfusion service moved to a new location on the second floor of Roberts Hospital. In 1999 there were approximately 33 full-time equivalents, including technologists, technicians, supervisors/managers, and clerical personnel. The laboratory operates 24 hours a day, 7 days a week, to provide blood for solid organ and bone marrow transplant patients, neonates, percutaneous umbilical transfusions, trauma cases, and many others. In 1999, approximately 50,000 U of blood and blood components were issued for transfusion. The mix is now at approximately 40% red cells (no whole blood) and 60% plasma components. The largest increase has been in the use of platelets for cancer and bone marrow transplant patients. The autologous transfusion program has increased from just an occasional event to 8% of all transfusions.

The HIV-AIDS era added many new responsibilities. The 1985 requirement of the Joint Commission on Accreditation of Healthcare Organizations to justify all transfusions, the introduction of "HIV look-back" in 1986, and many new Food and Drug Administration regulatory requirements markedly increased the work of the entire blood bank staff. Food and Drug Administration inspections became much stricter and went from lasting a few hours to lasting 7 days or more. The transfusion service is the most inspected part of BUMC's laboratories and includes site visits and interviews from the Food and Drug Administration, the Joint Commission on Accreditation of Healthcare Organizations, the American Association of Blood Banks, and the College of American Pathologists.

With the discovery of the hepatitis C virus (HCV), previously known to cause non-A, non-B hepatitis, a major effort was

undertaken in 1988 to reduce further the incidence of transfusion-transmitted hepatitis. Laboratory tests for the detection of antibodies to HCV were developed to exclude potentially infectious blood donors. Testing introduced in 1990, along with stricter selection of donors, reduced successfully the incidence of post-transfusion hepatitis from 1 in 200 to <1 in 100,000.

To reach individuals who may have been infected by blood transfusions before testing, Secretary of Health and Human Services Donna E. Shalala announced in January 1998 that the Department of Health and Human Services would implement measures recommended by its advisory committee on blood safety and availability. These measures (revised in March 1998) included a direct notification effort to reach individuals who received transfusions from donors who later tested positive for hepatitis C virus and a public provider education effort directed at all persons at risk of hepatitis C. Secretary Shalala also pledged to go beyond the committee's recommendations by evaluating the initial efforts and identifying ways to address unmet needs. She instructed the Centers for Disease Control and Prevention and the Food and Drug Administration to develop plans to carry out such efforts. These efforts are ongoing.

The instigation of the hepatitis C "look-back" in March 1998 caused blood collection centers to identify blood donors who were seropositive since initiating the second-generation hepatitis C/HIV testing in 1999.

A "window period" exists between the time a blood donor contracts an infectious disease, such as hepatitis C, and its detection by standard serological tests that detect the presence of antibody. Because of this delay in antibody response, about 2 cases of HIV transmission and 100 cases of HCV transmission occur every year in patients who are transfused in the USA. In an attempt to make the nation's blood supply even safer, a new test for the virus is being used. The nucleic acid test can detect minuscule amounts of HCV and HIV present in blood even before the donor's body can recognize the infection and form antibodies. This test will help ensure fewer cases of blood-transmitted viral infections by identifying blood donors who may not have viral antibodies present.

Furthermore, the Food and Drug Administration has an approved supplemental test to confirm screening results for antibodies to hepatitis C. The new test, called the RIBA HCV 3.0 Strip Immunoblot Assay, is used to test blood specimens that have already repeatedly tested reactive on licensed screening tests. This new test can detect one more type of antibody to HCV than the previous supplemental test and is better at distinguishing truly positive from falsely positive test results (14).

Advances in technology and instrumentation

Rapid advances in technology in the period from 1980 to 2000 made many changes possible. High-volume automated instruments were available before the 1980s, but technological changes greatly improved their performance. Dr. Race, Dr. Tillery, and Dr. Dysert have had to make decisions about obtaining technology: on the one hand, they have not wanted to begin a new service too soon, but on the other hand, they have not wanted to enter a service too late to be viewed as a leader. The chairmen have always taken great pride in making BUMC a leader and, in that effort, they have had the full support of the chief

executive officers. BUMC has also made effective use of industry partnerships, in which pathologists improve and validate new technologies. These partnerships are in fields in which BUMC laboratories have particular professional strength and desirably high patient volume.

A major trend evident during the 1980-to-2000 period was the development and expanding use of “dry chemistry” or “dry testing” processes (changes as innovative as, perhaps, Dr. Adolf Lorenz’ development of “dry surgery” a century earlier, which was so influential in establishing the Texas Baptist Memorial Sanitarium). These technologies led to more efficient, high-volume testing with smaller, more reliable, and more accurate instruments. The new systems also led to lower costs in testing since reagents were used in much smaller amounts. Many tests were also developed in the enzyme-linked immunological testing area, making it possible to do sophisticated testing on a routine basis. By using these techniques, more tests could be performed on-site by less-specialized personnel with very reliable results. These changes were pursued aggressively in BUMC laboratories and were a major boon to the functions of the laboratories.

At the same time these advances were being made at BUMC, major referral laboratories were being developed at the University of Utah, Mayo Clinic, Nichols Laboratories, and elsewhere that provided improved reference laboratory testing services. With these, BUMC’s pathology department could obtain the more specialized, expensive tests that were needed without having to develop them in house.

Diagnostic molecular laboratory

Because of revolutionary advancements taking place in the fields of genetics and molecular diagnostics, a new molecular pathology service was established in 2002. Drs. George Netto and Rana Saad head this service. The new laboratory provides state-of-the-art diagnostic and prognostic assays in the areas of oncology, infectious diseases, and genetic diseases, as BHCS embarks on targeted genetic therapy programs for cancer patients.

Laboratory information system

The continuing development of BHCS’s laboratory services and reorganization of the laboratories in accordance with the core laboratory concept were paralleled by development of a comprehensive, sophisticated, and automated laboratory information system. Despite the size and complexities of BUMC’s laboratory services, they had never been served by a dedicated information system matched to the professional and technical requirements of pathology and laboratory medicine. While BUMC had long had a central hospital information system, there was no already developed laboratory-oriented information subsystem that was compatible with the BUMC system and could accommodate the needs of such a large, detailed laboratory complex as the one at BUMC.

In about 1987, therefore, it was considered essential by BHCS’s pathologists that a major effort be made to select and obtain a laboratory information system that could provide the massive amounts of data processing and control capacity needed by BUMC’s laboratories.

Drs. Peter Dysert, Charles Rietz, and James Aguanno—heads of the three major components of BUMC’s reorganized laboratories—led the effort to get an appropriate computer system

to meet laboratory needs and, at the same time, interface with the extant hospital information system. The three major unit heads, as well as many other professionals and technicians in the BUMC laboratories, developed a basic design and selected an appropriate system.

In 1989, after the many months of work by BUMC’s staff, Cerner, the new laboratory system, arrived and was installed and tested. From the beginning, the system has functioned superbly and provided the links among physicians, laboratory data, and laboratory expertise that had not previously been available.

Installation of the information system was one of the greater accomplishments of the department in the period between 1980 and 2000. The laboratory reorganization as well as installation of the laboratory information system contributed directly to the improvement of patient care and service to medical staff members. Sophistication in information services was especially important at BUMC since the institution has so many centers that need accurate, timely laboratory testing and information delivery to function. This is particularly true for the solid organ transplantation and bone marrow transplantation services, which require large amounts of testing. Timeliness of the delivery of results is essential to achieve satisfactory outcomes in the treatment of those patients. The BUMC laboratory system now meets both volume and time requirements.

Reference laboratory partnership

Establishing a reference laboratory owned by BHCS and then merging it with another reference laboratory was another significant effort led by BUMC’s pathologists in the 1980s. The development of a reference laboratory by a major medical center to provide services to other institutions and physicians in the region was quite in keeping with developments elsewhere in the 1980s and 1990s. Experienced regional laboratory executives have pointed out that region-serving laboratories have achieved better utilization of capacity; reduced cost per reportable test result; new revenues; improved physician relationships; better support for the inpatient-to-outpatient strategy shift; access to capital; and a better communications system (15).

The Plaza Reference Laboratory was established at BUMC in 1974 as a taxable enterprise owned by BHCS. William S. Carter, executive vice president of BHCS, served as president of the corporation. While the laboratory was successful in terms of quality of services provided to hospitals and physicians, the volume of testing was not sufficient to achieve competitive costs in a market increasingly dominated by national or regional commercial laboratories. To be fully competitive, Plaza Reference Laboratory would have needed to produce \$8 million to \$25 million per year of gross revenue at competitive prices. This level of sales was never achieved.

BHCS decided, therefore, to look for a large reference laboratory with which it might enter into a partnership or some similar arrangement to give it far greater market access and access to capital for expansion. Numerous hospitals across the country had chosen to have outside laboratories take over their hospital laboratories under contracts. While BUMC never considered contracting for another entity to manage its in-house laboratories, the potential to merge the Plaza Reference Laboratory with another reference laboratory seemed to offer promise.

The Nichols Institute Laboratory, with its major reference laboratory in southern California, was one of a number of commercial laboratory companies considered. While other commercial laboratory companies made viable proposals, Nichols was considered more professional and less commercial than others. Nichols was well known for sophisticated testing and had been used for some time by BUMC laboratories and physicians as a reference source for some infrequently needed tests not routinely performed at BUMC. Dr. John S. Fordtran, then chief of internal medicine at BUMC, believed that selecting Nichols would be seen by BUMC medical staff members as “a reach for quality” rather than as just joining with a commercial laboratory company.

After prolonged discussions and detailed negotiations, BHCS entered into a joint venture with Nichols. The venture was structured as a limited partnership with Nichols as the general and managing partner and BHCS and other Dallas and Fort Worth health systems as limited partners. Each participating limited partner—BHCS, Presbyterian Hospital of Dallas, and the Harris Methodist Health System—agreed to transfer its reference laboratory business to the new entity.

Nichols Laboratory built a regional reference laboratory near the Dallas–Fort Worth airport to provide reference laboratory services to all hospitals that might be interested as well as to provide laboratory services for former and new Nichols customer hospitals in the North Texas area and beyond.

Attempts were made to develop and provide the reference laboratory services BHCS, BUMC, and other limited partner institutions would like to purchase on a negotiated, “arms-length” basis from the new regional reference laboratory. However, the new regional laboratory had difficulties with testing logistics as well as with its laboratory information system and communications system. In addition, there was little physician support at BUMC since most hospital physicians tend to believe that their laboratory tests should be done on site to provide the best and most timely results and that physicians should have immediate access to the responsible pathologists. Nichols reference laboratory administrators were not fully effective in building confidence on the part of pathologists and medical staff members at the limited partner institutions. With the deterioration of service levels, the partnership was dissolved in 1989.

After termination of the reference laboratory as a joint venture, effort was made to develop BUMC’s laboratories as a central service source for all BHCS-affiliated hospitals. BUMC laboratories developed close affiliations with other hospitals’ laboratories as well as with BHCS outpatient centers as these were developed in the 1990s. This approach yielded cost-effectiveness, timeliness of testing and reporting, and reliability of services throughout BHCS.

Pathology residency

As previously noted, Dr. George J. Race served as director of the pathology residency training program from the time of his arrival in the department in 1959 until he left the department in 1986 to head the Baylor Research Foundation. Dr. Dan Savino, chief of surgical pathology, served as director of the program from 1986 until 1991. Dr. Weldon Tillery, while director of the laboratories from 1986 until 1998, also served as pathology

residency program director. In 1999, Dr. George Netto became director of the pathology residency. The current director is Dr. Lesley Kresie.

BHCS’s pathology residency training program continues to enjoy a very good reputation and attracts many applicants. Most of the trainees come from the surrounding 5-state region. Many applicants, however, are from other areas of the country. In 2000, BUMC had 18 approved pathology resident trainee positions. These are consistently filled.

There have been 287 pathology trainees in the department since about 1950. With BUMC providing continuing support and enjoying an outstanding national image, the program will continue to be one of the better ones in the USA.

Regulatory and legal changes

Major changes for pathologists, clinical laboratories, and hospitals occurred in the 1960s at the inception of Medicare and as more and more laboratory work was financed by Medicare. Amendments to the Medicare law in 1967 provided for 100% reimbursement for inpatients to hospital-based physicians. Hospital outpatient diagnostic services were transferred to part B of Medicare. In the same year, the Clinical Laboratory Improvement Act was also passed and established minimum quality requirements for clinical laboratories engaged in interstate commerce to participate in Medicare. The act imposed significant administrative and cost burdens on hospitals and pathology groups of BHCS and other health systems.

In 1972, >100 amendments to the Medicare Act were adopted. Fee schedules for routine laboratory work were established on the basis of the lowest charges paid within a region. Reimbursement for teaching physicians was transferred to Medicare part A. In addition, Professional Standards Review Organizations were given responsibility for review of Medicare services, including those provided by pathologists.

In Texas and other states, the number of malpractice suits filed against pathologists as well as other physicians increased rapidly. As hospitals lost charitable immunity, they along with pathologists were subject to increasing numbers of claims and suits.

In the 1970s, 1980s, and 1990s, laws and government regulations affecting hospitals and physicians were adopted and enforced with increasing intensity. Medicare-Medicaid Fraud and Abuse Amendments were adopted in 1977. One section called for disclosure of ownership of $\geq 5\%$ in a facility such as an independent laboratory in order for the facility to participate in Medicare and Medicaid.

Pressure on reimbursement rates was increased progressively. In 1978, for example, “lowest-charge” reimbursement was established for 12 commonly used laboratory tests. A year later, an “automated fee schedule” for Medicare was established for laboratory tests in some laboratories.

The Tax Equity and Fiscal Responsibility Act, adopted in 1982, brought laboratories along with other units of hospitals under reimbursement limits. The Health Care Financing Administration was given authority to limit reimbursement to pathologists under “reasonable compensation equivalents.” In 1983, a year later, however, these reasonable compensation equivalents were replaced by a prospective payment system based on “diagnosis-related groups.”

In 1987, under the Omnibus Budget Reconciliation Act, previous allowances for return on equity for hospital outpatient departments, including laboratories, were eliminated and Medicare reimbursements were reduced, adversely affecting both BUMC and the pathologists. In 1988, the Clinical Laboratories Improvement Act extended federal jurisdiction for the regulation of clinical laboratory quality to all clinical laboratories in the USA. The act also provided for Medicare coverage of selected preventive laboratory services, including Pap smears every 3 years. In the following year, the Omnibus Budget Reconciliation Act of 1990 reduced laboratory fee schedules again and barred self-referral to laboratories owned by physicians. In 1990, fee schedules were again reduced, and shell laboratories were defined as those that do not do on site at least 70% of the tests for which they have received requisitions.

In 1992, the first regulations of the Clinical Laboratories Improvement Act 1988 took effect. At the same time, final regulations of the 1987 act were implemented, as was the Stark self-referral ban. In the late 1990s, Medicare regulations continued to impose confusing and onerous regulations on laboratory medicine at BUMC, throughout BHCS, and in other health care systems across the country. At century's end, laboratory medicine and the practice of pathology may well be the most thoroughly regulated and price-controlled segment of health care in America (16).

Managed care

In the early 1980s, the concept of managed care as a means of controlling the cost of health care to the individual, employer, and government was gradually developed and began to be adopted across the nation. While Texas and Dallas were slower than some areas of California and the upper Midwest in embracing managed care, by about 1984 it was having a small but growing impact on BUMC and the BUMC medical staff, including the laboratories and professional pathology services.

At the outset, there was a movement toward the development of health maintenance organizations, preferred provider organizations, and independent practice organizations for physicians—all designed to control and contain the cost of medical care. Major changes began to be made in the way patients were served and laboratory services for them were provided and paid for.

PATHOLOGY AND LABORATORY MEDICINE IN THE 21ST CENTURY

Pathology and laboratory medicine developed rapidly during the 20th century and are likely to develop even more rapidly in the 21st century. BHCS physicians are poised to provide the best in patient care because of their main focus on patients—rather than on teaching and research, as is the case at academic medical centers.

Medical staff members of BUMC and other components of BHCS will make early use of scientific advances to enhance both diagnosis and treatment of patients. Experience gained under BHCS's tertiary care programs at BUMC and specialized hospitals and centers on the Dallas campus and from research at the Baylor Institute for Immunology Research will contribute to cancer diagnosis and treatment, organ transplantation, and other tertiary-level care throughout BHCS and elsewhere.

In addition to new test development, an early undertaking will be creating a single patient record—a lifetime record—based on data in the clinical laboratory record. With such a record, a patient seen at BUMC and at Baylor Medical Center at Garland, for example, will know that tests done and recorded at one BHCS institution will be accessible at other BHCS units.

Standardization will allow BHCS to make sure it has equal quality at all of its sites. The goal is to standardize methodologies, collect feedback across facilities, and aggregate and analyze results. Through these means, pathologists can develop organizational confidence around each standardized procedure.

To provide the highest-quality care, BHCS will need to continue to attract, retain, and support the professional practices of increasing numbers of physicians and medical scientists. New professional skills will need to be available. Physicians and scientists retiring from practice will need to be replaced. Moreover, future chiefs of services will need to be attracted in competition with academic medical centers, medical schools, voluntary hospitals and health systems, health care companies, pharmaceutical companies, research institutes, and other entities.

A final challenge relates to education. In pathology and laboratory medicine, more residencies, fellowships, and PhD programs will need to be offered by BHCS. Exceptionally well qualified individuals will need to be attracted as residents and fellows. PhD and postdoctoral opportunities will need to be provided at BUMC and in cooperation with medical schools and graduate schools of universities.

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