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Otolaryngology–Head and Neck Surgery at Johns Hopkins: The First 100 Years (1914–2014)

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Early Days of Otolaryngology at Johns Hopkins

As The Johns Hopkins Hospital opened in 1889 (Fig. 1), the Outpatient Department was organized under the direction of William S. Halsted.¹ Nine divisions were initially formed: 1) the Department of General Medicine, directed by William Osler; 2) the Department of Diseases of Children, directed by William Osler and W.D. Booker; 3) the Department of Nervous Diseases, directed by William Osler and H.M. Thomas; 4) the Department of General Surgery, directed by William S. Halsted and John M.T. Finney; 5) the Department of Genitourinary Diseases, directed by William S. Halsted and James Brown; 6) the Department of Gynecology, directed by Howard A. Kelly and Hunter Robb; 7) the Department of Ophthalmology and Otology, directed by Samuel Theobald and Robert L. Randolph; 8) the Department of Laryngology, directed by John N. Mackenzie; and 9) the Department of Dermatology, directed by R.B. Morrison.

From the beginning, there was controversy about how these departments were run. Most of the physicians were private practitioners and served without any compensation for their clinical or teaching efforts. The space provided to see patients was crowded, poorly equipped, and understaffed. William S. Halsted assigned no public beds to the clinical staff; therefore, many surgical procedures were done in the clinic exam rooms, with the patients discharged after ether anesthesia. All otolaryngology cases that required the main operating rooms were referred to the general surgery staff and operated on by John M.T. Finney,

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Joseph C. Bloodgood, or the resident surgeons. Thus, surgeons with little if any otolaryngology training performed the surgery, whereas staff members who were experienced in the field were excluded from the operating room.¹ This system was kept in place until 1912.

As was commonly the practice at that time, otology and laryngology were relegated to separate departments. It was not unusual for physicians of that time to specialize in diseases of the eyes, ears, nose, and throat. Such was the case with Samuel Theobald, an 1867 graduate of the University of Maryland School of Medicine, Baltimore, who studied in Vienna and London before practicing in Baltimore. He was appointed to the Johns Hopkins staff in 1896 and continued to head the ophthalmology section of surgery until his retirement in 1925. Later, he was a founder of the Baltimore Eye, Ear, and Throat Charity Hospital, one of the predecessors of Greater Baltimore Medical Center (GBMC).

Robert L. Randolph was also a University of Maryland graduate, receiving his MD in 1884. He sought training in Vienna and was for a time the assistant to the chief of the Vienna Polyclinic Ophthalmology Department. After returning to Baltimore, Randolph was appointed to the Johns Hopkins staff in 1896 and served until his death in 1919, by which time he was an associate professor of clinical ophthalmology and otology. Randolph had a wide reputation for innovative lectures and clinical instruction.

John N. Mackenzie was among several individuals in Baltimore who during the late 19th century became interested in laryngology. He graduated from the University of Virginia School of Medicine, Charlottesville, in 1876.² After study at Metropolitan Throat Hospital and Dispensary of New York, he traveled abroad in 1879, studied in Vienna and Munich, and then served as chief of clinic in laryngology under Morrell Mackenzie (not related) at the Hospital for Diseases of the Throat and Chest in London. Morrell Mackenzie, perhaps the leading European laryngologist of his generation, managed the infamous affair of Kaiser Friedrich III's laryngeal cancer in the 1880s. John N. Mackenzie was appointed to the Johns Hopkins staff in 1889.

In 1912, William S. Halsted (Fig. 2) asked one of his general surgery residents, Samuel J. Crowe, to cancel his planned neurosurgery career in Boston with Harvey Cushing, his mentor, who had been appointed professor and chair of surgery at Harvard in the same year.¹ Halsted asked Crowe to instead remain in Baltimore to lead the first Division of Otology and Laryngology. Crowe protested that he knew nothing about these specialties, but an invitation from Halsted to become a member of his surgical staff could not be refused lightly. In 1912, Crowe's acceptance of Halsted's offer marked the formal start of the Division of Otology and Laryngology at The Johns Hopkins Hospital.

CHIEFS AND DIRECTORS OF OTOLARYNGOLOGY AT THE JOHNS HOPKINS HOSPITAL

Samuel J. Crowe (1912–1962)

Samuel J. Crowe (Figs. 3 and 4) was born in Virginia on April 16, 1883. His father, a native of Washington County, Virginia, decided to move to Atlanta, Georgia, because of his wife's

health.¹ There he attended Emory College for a year (1901–1902) before transferring to the University of Georgia in Athens, where he received his bachelor's degree in 1904. Although he initially desired to become an electrical engineer, his father, a physician, coerced him to study medicine instead. In the fall of 1904, Crowe matriculated into the Johns Hopkins School of Medicine, much against his will and with no interest in medicine (Lee Williams, written personal communication, 2013).

Fate soon intervened and directed the course of what would be an outstanding career in medicine. At the end of his first year of medical school, Crowe embarked on a camping trip to the North Carolina mountains with two friends. With no maps or guides, the team of medical students trekked through the rugged terrain for several weeks with only two horses and a carriage in their company. One morning, while tending to the animals, Crowe noticed that one of the horses was stiff at every joint, unable to travel any farther. While seeking aid, Crowe came across an older man who directed him to “Doc Halsted,” who lived 2 miles up the road. Leaving the crippled horse behind, Crowe met William S. Halsted for the first time and was impressed by his kindness and diligence to treat the animal. Over the course of the next week, Crowe and Halsted would examine and treat the animal each morning and thereafter take a walk in the Halsted dahlia garden while talking about their own experiences. One morning, Crowe hesitantly confessed to Halsted his feelings about a career in medicine. After a long pause, Halsted responded with the words that would greatly change Crowe forever. According to Crowe¹:

[He] said that medicine was a living, growing, constantly changing, and in many ways the most rewarding of all professions. The doctor, he said, must know how to diagnose and treat the sick, but he must also try to find by laboratory work and clinical research new ways to reduce the number of cripples from disease who constantly flow into our hospitals; that monetary rewards are necessary only to the extent that they allow the doctor to care for his family, to travel in order to acquire new ideas, and to have the leisure and peace of mind to permit him to think, to read, and to try to add something of lasting value to medicine during his lifetime.

With a new perspective on medicine, Crowe thoroughly enjoyed the remaining 3 years of medical school. During his third year, Crowe was greatly inspired by the pioneering work in neurosurgery of Harvey Cushing, one of his professors at the time. Immediately upon graduation, he was appointed assistant in surgery and assigned to work with Cushing on the pituitary gland in the Hunterian Laboratory (Lee Williams, personal communication). At the end of the year, Crowe was appointed assistant resident surgeon and was in charge of the neurosurgical cases under Cushing's supervision, serving in that capacity for a year (1909–1910). Afterward, he returned to the Hunterian Laboratory to work with Cushing for an additional 2 years, until Cushing accepted an invitation to be director of surgery at Harvard University.

As the new head of the division only 4 years out of medical school, Crowe found himself at odds with members of the ear, nose, and throat (ENT) clinical staff. With no formal training in otolaryngology, he was given operating room privileges and the responsibility for supervising much more experienced clinical staff. This was unacceptable to the existing clinicians, who all resigned in short order.¹ Crowe was then responsible for examining 25 to

30 patients every afternoon. Due to the laborious process of writing many histories and examination notes, Crowe was the first to hire a stenographer, which later became commonplace in other departments. In addition, due to the excessive coughing, gagging, and vomiting caused by the use of ether during surgeries, Crowe was the first to employ the use of a water suction pump in the operating rooms of The Johns Hopkins Hospital (Lee Williams, written, 2013). After a year, Harry R Slack Jr., a 1912 graduate of the Johns Hopkins University School of Medicine, began assisting Crowe every afternoon in the dispensary, and in 1913 he became the first resident in otolaryngology. Without training and experience in otolaryngology, Crowe sought training in Europe. In 1913, he traveled to Germany with Slack to work with Gustav Killian at the University of Freiburg and then to Vienna to work with Gustav Alexander.

Crowe published his first article pertaining to otolaryngology in the *Bulletin of The Johns Hopkins Hospital* on the relation of tonsillar and nasopharyngeal infections to general systemic disorders in 1917.³ Although he was never a prolific writer, a number of his articles were landmarks in the field. In 1917 and the years succeeding it, the division began to grow as the yearly rotation of new trainees attracted future well-known names in the field such as John W. Baylor, J. Julian Chisolm, Edwin N. Broyles, Leroy M. Polvogt, and John E. Bordley. In 1924, with financial support from the General Educational Board of the Rockefeller Foundation, the division established the Otological Research Laboratory for the study of deafness, which included the first human temporal bone collection in the United States. The temporal bone collection was also unique for the availability of audiometric data with which to correlate microscopic findings in the ear. Stacy R. Guild, formerly an associate professor of anatomy at the University of Michigan, was invited to Johns Hopkins to be director of the Otological Research Laboratory.

From 1931 through 1932, Crowe, in collaboration with Guild and Walter Hughson, presented his work on deafness in the Harvey Lecture Series. One of the most productive of its kind, Crowe's department (Fig. 4) was built almost entirely upon outside grants, many of which were obtained through gifts from his private patients. A long line of residents and fellows received basic training in problems of deafness through the Otological Research Laboratory.

Crowe retired in 1952 after 40 years as chief. When he was close to retirement, Director of Surgery Alfred Blalock asked him to write the history of the Department of Surgery and its divisions during the William S. Halsted years. Crowe agreed and in 1955 completed his book, *Halsted of Johns Hopkins: The Man and His Men*,⁴ just a few hours before suffering a massive coronary occlusion. He died 2 weeks later on November 13, 1955, at the age of 71.

As the first chief of otolaryngology, Crowe also had the longest tenure of any leader. Program alumni who rose to national prominence as leaders in the specialty include John Kirchner (Chief of Otolaryngology, Yale, 1951–1980) and Bordley.

John E. Bordley (1952–1969)

Born in Baltimore on November 8, 1902, John E. Bordley (Figs. 5 and 6) was the son, grandson, and great-grandson of physicians. After graduating from Yale in 1925, Bordley

entered the Johns Hopkins University School of Medicine, graduating in 1929. While he was a medical student, discussions at home frequently involved both ophthalmology and otolaryngology. During his senior year, Bordley conferred with Samuel J. Crowe, who advised that he take surgical training at Union Memorial Hospital in Baltimore before entering specialty training at Johns Hopkins. During his 2 years of general surgery, Bordley met and married Ellen Bruce Fisher, the daughter of one of the leading surgeons at Union Memorial Hospital. This created a significant problem because there was a longstanding tradition that Johns Hopkins surgical residents could not be married. In order to enter the Johns Hopkins otolaryngology residency, Bordley first had to obtain permission from Crowe, who in turn had to seek the approval of the hospital director. Fortunately, this was given and Bordley started his training (unpublished interview of John E. Bordley by Dr. Michael M.E. Johns, 1986). During his 3 years of residency, Bordley spent much time involved with temporal bone research under the guidance of Stacy R. Guild. This was his first exposure to research in otolaryngology, and it had a lasting influence on his career.

After finishing residency, Bordley entered private practice and also continued his basic research in otolaryngology. He blocked 2 days a week for research and managed to scrape together funding for these investigations. At the time, scientific grants were quite rare. This independent work resulted in two articles: "Effect of Lesions of the Tympanic Membrane on the Hearing Acuity: Observations on Experimental Animal and on Man" in 1937⁵ and "The Effect of Small Lesions on the Organ of Corti on Cochlear Potentials" in 1942.⁶ This pattern of professional endeavors persisted throughout his career. Bordley always tried to use scientific investigation to advance the knowledge base to improve clinical care. This was evident through the years he served as division director, which he assumed in 1952. The temporal bone research laboratory was expanded during his years as director and was closely related to the future Hearing and Speech Center.

After the United States entered World War II, Bordley became a member of the Johns Hopkins 118th General Hospital, a tour of duty that took him to New Guinea, Australia, and the Philippines. Most of the aircraft at that time did not have pressurized cabins; therefore, Eustachian tube dysfunction and aerotitis were frequent. Based on earlier work by Crowe in the Otolological Research Laboratory,⁷ Bordley and Crowe were consulted by the U.S. military in the use of radium-coated applicators to reduce congestion and help combat pilots perform better. The Johns Hopkins team was designated the maxillofacial unit for the South Pacific. Joint experience with general surgery and dentistry contributed to significant experience and expertise in this area and led to widening of the scope of practice to include maxillofacial surgery (unpublished interview of John E. Bordley by Dr. Michael M.E. Johns, 1986).

After the war, Bordley returned to Johns Hopkins and became interested in the detection of hearing loss in infants and the rehabilitation of hearing loss in veterans and adults. Hazel Burke (1913–1990), who was Bordley's administrative assistant while he was at Johns Hopkins (1937–1949) and his nursing assistant while he served in the South Pacific, was an important force behind Bordley's accomplishments (www.medicalarchives.jhmi.edu/papers/burke.html).

From 1960 to 1964, Bordley served on the governing council of the National Institute for Neurological Diseases and Blindness. As chair of the Training Grant Committee, he was the driving force behind establishing training grants to develop a group of scientifically based otolaryngologists who would serve as leaders for the next generation. These grants were very successful and provided training programs with funds to pay trainees for the first time, support for good teachers, and funds for the development of laboratories. In this capacity, Bordley promoted change in residency education by linking the availability of National Institutes of Health (NIH) training funds to compliance with new program requirements and the outcome of a formal review and site visit (unpublished interview of John E. Bordley by Dr. Michael M.E. Johns, 1986).

One of the eight research laboratories established during Bordley's tenure as director, the Neurophysiology Laboratory at Johns Hopkins, was very busy with visiting otolaryngology research physicians from 1959 to 1966. Participants included future leaders in otolaryngology and audiology, such as Robert J. Ruben, Ugo Fisch, William Hudson, Bobby Alford, and Charles Berlin. In collaboration with William G. Hardy, Albert Lieberman, and Diran Mikaelian, Robert Glacken, as the electronics technician, provided invaluable services in the construction of novel electrophysiological equipment. The concomitant rise of the Hearing and Speech Center in the division added to this research environment and further integrated the science with clinical activities.

During Bordley's tenure, the department trained several leaders, including Newton Fischer (founding chair, University of North Carolina, Chapel Hill, 1952–1982), Bobby Alford (chair, Baylor University, 1967–2010), Robert Ruben (chair, Albert Einstein College of Medicine, 1968–1998), Patrick Brookhouser (founding director of the Boys Town National Research Hospital, Omaha Nebraska, 1967), and Alvin Wenger (first chief of otolaryngology at GBMC, 1949). Under Bordley's stewardship, the Andelot Chair was established for the director from funds provided by members of the Dupont family.

George T. Nager (1969–1984)

The addition of George T. Nager (Figs. 7 and 8) to the Department of Otolaryngology culminated a longstanding tradition of international learning and collaboration. A native of Zurich, Switzerland, Nager was the son of Felix Robert Nager, the first chair of the Department of Otorhinolaryngology at the University of Zurich. As a graduate of the University of Zurich's otolaryngology residency program, Nager was invited to train at Johns Hopkins on exchange with Fred Linthicum for 6 months in 1951, based on an agreement between Samuel J. Crowe and Luzius Rüedi, then chair of otolaryngology at the University of Zurich. During this academic exchange, Nager also spent some time visiting other leaders in the field, such as Leroy Schall at Harvard University, John Lindsay at the University of Chicago, and Howard and William House at the House Ear Clinic in Los Angeles. These experiences inspired Nager to stay at Johns Hopkins to follow in the footsteps of Stacy R. Guild in preserving and expanding the temporal bone library, which at that time served as one of the largest collections of temporal bone specimens in the world.

In 1969, Nager was named the Andelot Professor and first director of the new Johns Hopkins Department of Otolaryngology, which had until then been a division of the Department of Surgery.

Nager's term as director marked another event in the long relationship between Johns Hopkins and the University of Zurich, which started with Harvey Cushing's influential visit with Professor Felix Robert Nager in about 1900, followed by Samuel J. Crowe's visit during World War I. Both men left Zurich inspired by the senior Professor Nager's work. Cushing delved into studies of the pituitary gland and refined surgical approaches for pituitary tumors and acoustic neuromas (Donlin Long, MD, PhD, written and oral communication, 2013), eventually enhancing the fields of endocrinology and neurosurgery, while Crowe and Guild established the temporal bone collection at Johns Hopkins. Nager's own academic work and his leadership of the department at Johns Hopkins represented a continuation of this legacy, including the institution's first collaboration between otolaryngologists and neurosurgeons in the surgical management of pituitary tumors and acoustic neuromas (Donlin Long, MD, PhD, personal communications). Otologists Michael Holliday and Douglas Mattox subsequently completed fellowships with Ugo Fisch at the University of Zurich and returned to build a very busy neurotology and skull base surgery service at Johns Hopkins.

Nager continued the tradition of discovery and training and expanded the scope of clinical care by the faculty to include head and neck oncology. He was a strong advocate for the expansion of the scope of ENT to include head and neck oncology and facial plastics, an effort that initially met intense resistance from general surgery. Nager was most admired for his compassion with patients and staff, devotion to teaching, and commitment to faculty development. As the first director of the new department, he set the foundation for high standards in the scholarly, clinical, and teaching pursuits of the faculty and trainees. Nager's reserved and polite persona belied an intense commitment to excellence in his faculty, which he modeled in his own conduct and performance. Among his hires were Haskins Kashima, Leonard Proctor, Michael Holliday, David Kennedy, Hugh DeFries, and Anthony Harris—all who were known as innovators in their fields of expertise.

Michael M.E. Johns (1984–1991)

Michael M.E. Johns (Figs. 9 and 10) was recruited in January 1984 to succeed George T. Nager as the Andelot Professor and Director. He had trained at the University of Michigan, Ann Arbor, served as assistant chief of otolaryngology at Walter Reed Army Hospital in Washington, DC, and was on the faculty of the University of Virginia before arriving in Baltimore in 1984. At a time when the specialty was undergoing vast changes in scope and practice, Johns brought a new perspective on how the department's goals should be set and achieved. The name of the department was immediately changed to Otolaryngology–Head and Neck Surgery (OHNS) to more accurately describe the full scope of the department's practice and activities.

Faculty members were encouraged to be leaders, not just locally but on a national and international level. To accomplish these aggressive goals, the faculty had to be expanded. Academic leaders in several subspecialties were recruited to expand or create new areas of

practice at Johns Hopkins, which was in keeping with the long-term goal of developing a leading department strong in clinical care, research, and teaching. This led to the formalization of subspecialty divisions within the department. These divisions (with their division heads) included head and neck surgery (John Price), rhinology (David Kennedy), facial plastic surgery (Ira Papel), otology/neurotology (Douglas Mattox), and pediatric otolaryngology (Robert M. Naclerio). Through these divisions, patient needs were better addressed, and the seeds were planted to encourage expansion of clinical practice and research. The volume of patient flow and surgical cases grew significantly, requiring further expansion of the faculty and a four-fold increase in operating room space. Through this expansion, the clinical budget of the department became positive within a year.

With the increased clinical activity, a need for better administrative oversight also arose. C. Alan Lyles, was hired to institute an organized plan for departmental expansion of doctors, residents, and support staff. The growing complexity of insurance benefits, health maintenance organizations, residency regulations, and human resource issues mandated a higher level of management.

In collaboration with the departments of biomedical engineering and neurosciences, the Center for Hearing Sciences was established in 1985. New leading scientists were recruited to the department, such as William Brownell, Paul Manis, and David Ryugo. This new center created opportunities for clinicians and scientists to work together in multidisciplinary teams, creating a legacy that is addressed in a future section. The Head and Neck Division also began research and clinical collaboration with experts in medical oncology and radiation oncology. These multidisciplinary efforts were well aligned with national funding priorities and attracted NIH support. This propelled the department to be one of the top-tier research-funded departments in the United States.

With the expansion of the clinical faculty and more research opportunities, the department was able to take on more trainees. The residency was expanded from three residents a year to five a year, and fellows in many divisions were accepted for subspecialty surgical and research experience. Part of the expansion involved the merger of the GBMC residency program into the Johns Hopkins system. Under the leadership of James Kelly, GBMC provided a source of expanded clinical training that remains a strength today. The vitality of the faculty and research programs allowed the department to compete successfully for an NIH research training grant, which not only allowed the department to provide significant research opportunities for its trainees but also allowed it to attract some of the very best resident applicants in the country.

Johns was fortunate over the early years of his term to have both John E. Bordley and George T. Nager as advisors on whom he could rely for advice based on their vast experience at Johns Hopkins. During the final 4 years of his directorship, Johns served simultaneously as associate dean for clinical affairs in The Johns Hopkins University School of Medicine. During that time, he led the design and construction of the Johns Hopkins Outpatient Center, which remains the primary home of the department today. He was then appointed dean of the medical faculty for Johns Hopkins in 1991. Johns subsequently moved to Emory University, where he served as Executive vice president for Health Affairs and

CEO and Chair of Emory Healthcare from 1996 to 2007 and as chancellor of Emory University from 2007 to 2012.

Charles W. Cummings (1991–2003)

Charles W. Cummings (Fig. 11) assumed the directorship of the department in 1991, succeeding Douglas Mattox, who was the interim director after Michael M.E. Johns became dean. Cummings, who was born in Boston, was a graduate of Dartmouth College, Hanover, New Hampshire, and the University of Virginia School of Medicine. He completed training in OHNS at the Massachusetts Eye and Ear Infirmary. He had served as chair of the OHNS Department at the University of Washington, Seattle, from 1978 to 1990.

In the early 1990s, the territorial conflicts continued with related surgical specialties regarding the control of head and neck surgery and facial plastic and reconstructive surgery cases. The department direction focused on expanding this domain of competency. Cummings' first recruit in 1992 was David Sidransky, a member of Bert Vogelstein's trendsetting molecular-biology research laboratory at Johns Hopkins. Sidransky rapidly developed an extraordinarily productive laboratory focused on genetic abnormalities not only of head and neck cancers but also of other epithelial tumors. Many seminal contributions, evolved from this laboratory in the next decade.

The department's emphasis became more focused on the academic sphere of OHNS and the establishment of a dual pathway within the residency training program. This eventuated in a successful application for a T32 training grant from the NIH, which enabled half of the incoming residents to be placed in a full-time 2-year research program encompassing the fertile field of the basic science departments as well as the internal research faculty (William Brownell, David Ryugo, Paul Manis, Brad May, and Sidransky).

The department enjoyed the number 1 funding position from the NIH in OHNS and related fields, and was the most funded surgical department at Johns Hopkins. Brownell, director of departmental research, was succeeded by Ryugo, who also championed the cause of resident research. During the 1990s, the department grew in all areas within the specialty with the establishment by David W. Eisele of the multidisciplinary Johns Hopkins Head and Neck Cancer Center, which accelerated the transfer of new information from the laboratory to the clinical arena. Wayne Koch championed this effort with his observations on the presence of P53 gene abnormalities and their association with head and neck cancer. In otology, John K. Niparko developed a program that successfully pushed the frontiers of cochlear prosthesis rehabilitation for the profoundly deafened and the use of outcome methodologies to demonstrate cost-effectiveness. With the department's recruitment of Lloyd B. Minor in 1993, the vestibular arena was brought more into focus, eventuating in the discovery of the superior semicircular canal dehiscence syndrome. With the assistance of Howard Francis, the Stacy R. Guild/George T. Nager human temporal bone collection was rescued from institutional obscurity and promptly restored as an invaluable resource for histopathological confirmation of otological syndromes. Rhinology also expanded during this time with the recruitment of Donald Leopold and Andrew Lane. Lane was successful in obtaining extramural funding, expanding the understanding of olfaction and inflammatory disorders of the paranasal sinus. Laryngology, which was already prominent because of seminal

contributions regarding respiratory papillomatosis made by Haskins Kashima and airway disorders by Bernard Marsh, expanded with the addition of Paul Flint in 1991. Collaborating with Cummings on vocal cord medialization and lateralization, Flint made substantial contributions to the care of patients with vocal fold paralysis. David Tunkel returned from fellowship to full-time faculty status in the department and shortly thereafter was named director of Pediatric Otolaryngology. He immediately made contributions to hypertrophic tonsils and obstructive sleep apnea and grew the division to national prominence.

The Division of Facial Plastic Surgery, young as a subspecialty, paved the way not only in facial cosmetic surgery but in head and neck reconstruction. The resulting collaboration between Ira Papel in private practice and full-time faculty in the new division led by John Frodel; then Richard Holt; and more recently, Patrick Byrne, established a successful academic model for training and program development in this field that persists today and is adopted nationally.

Johns Hopkins Bayview Medical Center became a more substantial component of the department and training program when Matthew Kashima assumed leadership of the department's division there. The contributions of John Saunders, a head and neck surgeon, to the training program at GBMC were one of the highlights.

Cummings stepped down as director in November 2003, and Lloyd B. Minor was appointed as the new director. Cummings continued to serve in a leadership capacity in Johns Hopkins Medicine, including as vice president and executive medical director of Johns Hopkins International (2005–2010) during a time of unparalleled growth in the institution's global expansion of its clinical and consulting services. He also subsequently served as interim director of the departments of dermatology (2007–2008) and orthopedic surgery (2011–2013).

Lloyd B. Minor (2008–2009)

Lloyd B. Minor (Fig. 12) came to Johns Hopkins in 1993 after completing a neurotology fellowship with Michael Glasscock in Nashville. He completed his OHNS training at the University of Chicago in 1992 following a 4-year research fellowship in vestibular neurophysiology with Jay Goldberg at the same institution. Minor was appointed director of the department in 2003 following a decade of personal academic accomplishments, which included the establishment of a world-class center of excellence in vestibular research, training, and care within the department.

During Minor's tenure as director, the department experienced another period of significant growth. As Minor worked vigorously to recruit and retain an outstanding faculty, annual research funding grew by more than 50 percent, and clinical activity grew by more than 30 percent. Much of Minor's tenure was focused on fiscal matters and reversing what had been a significant erosion of the department's reimbursements for clinic visits and surgical procedures. To accomplish this, Minor instituted a more horizontal leadership and governance structure, which empowered individual faculty members and division directors. Governance principles emphasized transparency, participation, and accountability.

Largely through philanthropy, Minor raised significant resources to support new and innovative programs and provide seed money for faculty research projects. In these projects, Minor emphasized the establishment of interdisciplinary programs in which scientists and clinicians could work together, including collaborations with engineers and computer scientists to develop advanced instrumentation for imaging and interventions, collaborations with neuroscientists and biomedical engineers to explore regeneration of the inner ear, and collaborations with public health scientists to conduct a clinical trial assessing the outcomes of cochlear implantation in children.

Under Minor's leadership, the department strengthened resident and fellow training. The faculty revamped the training curriculum and with the help of Nasir Bhatti founded a nationally recognized program to assess procedural competency in residents. With Howard Francis as residency program director, Minor also implemented training for improving the efficacy of faculty and residents as teachers and learners in areas such as giving and receiving feedback and professionalism. Minor also established an innovative partnership with the Milton J. Dance Center, an independent head and neck cancer institute located at the GBMC, which expanded the clinical, research, and teaching mission of the Head and Neck Division. Another important focus of Minor's tenure was enhancing diversity.

Under Minor's tenure, the department initiated a comprehensive effort to recruit and retain underrepresented minorities and women. The department established a diversity committee whose charge was to facilitate a climate of inclusion. Through the Women in Otolaryngology Committee, prominent women otolaryngologists came to the department as visiting professors. Under Minor's leadership, the faculty also established a professionalism task force to consider how the department could promote a more welcoming and inclusive environment for all.

To help build the pipeline for underrepresented minority candidates to the specialty, Minor worked with the departmental diversity committee to establish a medical student mentoring clerkship program for underrepresented students. This program, the first and only mentoring program of its kind in otolaryngology, brought students from historically black medical schools to Johns Hopkins for clinical and research rotations, providing them with transportation, housing, and living expenses.

In 2009, Minor was appointed provost and chief academic officer of The Johns Hopkins University as well as university distinguished service professor of OHNS. In 2012, he left Johns Hopkins to become dean of the Stanford University School of Medicine. John K Niparko served as interim director from 2009 to 2012.

David W. Eisele (2012–Present)

In 2012, David W. Eisele (Fig. 13) returned to Johns Hopkins to become director of the department after serving as professor and chairman of the Department of OHNS at the University of California, San Francisco (UCSF) for 11 years. Eisele grew up in Clearwater, Florida, and received his undergraduate degree from Dartmouth College and his medical degree from Cornell University Medical College, New York. After completing his residency training under Charles W. Cummings at the University of Washington in 1988, he was

recruited by Dr. Johns to join the Johns Hopkins faculty in the Head and Neck Surgery Division. Eisele eventually became chief of the Division of Head and Neck Oncology at Johns Hopkins and served in that role until the time of his departure to UCSF in 2001.

Upon his return, Eisele established four vice-director positions in the department: education, research, clinical, and general otolaryngology at Johns Hopkins Bayview Medical Center. In addition, new departmental committees were created, including a finance committee and a promotions committee. To continue and expand departmental diversity efforts, a directorship of diversity and inclusion was created. Fundraising efforts were intensified. As a result, a number of new annual lectureships were endowed. A web-master was hired, and the department's Web site and marketing efforts were enhanced. The department's clinical footprint was expanded further into the Washington, DC, suburban area known as the National Capital Region at Suburban Hospital, which became part of Johns Hopkins Medicine in 2009. Additional faculty recruitments and clinical programmatic growth are planned for Sibley Memorial Hospital in Washington, DC, which joined Johns Hopkins Medicine in 2010, and All Children's Hospital in St. Petersburg, Florida, which joined Johns Hopkins in 2011. International clinical care and education efforts were also expanded.

The department is now one of the largest and most comprehensive of its kind in the United States. There are 48 full-time clinical faculty, 16 full-time research faculty, and 24 affiliate staff (audiologists and speech language pathologists). Hospital practice sites include The Johns Hopkins Hospital, Johns Hopkins Bayview Medical Center, Suburban Hospital, and GBMC. In addition, outpatient facilities now include Green Spring Station, White Marsh, and Bethesda. Future outpatient clinical care sites are planned in Northern Virginia. Recently, central patient scheduling has been instituted, improving patient access and convenience.

Basic science and clinical research span the specialty, and the department has recently expanded its research efforts with the recruitment of new basic scientists and clinician scientists. Ties with the NIH have grown, with several department faculty members having intramural funding there. In addition, several NIH faculty members have recently been given joint Johns Hopkins faculty appointments.

In alignment with national trends and institutional priorities, Eisele has navigated a trajectory for the department that includes leadership in graduate medical education and faculty development. Combined with an emphasis on professionalism and inclusion, these efforts are designed to establish models of team efficacy, patient-centered care, and interdisciplinary innovation.

Histories of the Department's Divisions

As the cumulative product of several leaders (Fig. 14) and their faculties built on a legacy of formalized resident education, clinical innovation, and bench-to-bedside discovery, the Johns Hopkins Department of OHNS has contributed significantly to the growing prominence of the specialty of OHNS in the United States. The structured training of surgeons under the leadership of William S. Halsted¹ was integrated with the process of inquiry to advance clinical care and establish new fields of practice. Harvey Cushing was a

prominent product of this training environment and widely acclaimed for birthing the fields of neurosurgery, endocrinology, anesthesia, and critical care medicine. Both Halsted and Cushing were influential mentors to Samuel J. Crowe, who then placed his new Division of Otolaryngology on a trajectory with similar commitment to advancing practice through research and teaching. The contribution of the department to U.S. innovation in otolaryngology over the past 100 years is further enhanced by the dissemination of these principles by Johns Hopkins faculty, residents, and fellows who have become national leaders in other institutions and professional societies. In the following sections, we recount the history of program building in the department by each subspecialty of OHNS, emphasizing watershed events that have shaped the department's mission, and its contributions to knowledge and practice in OHNS and its related fields.

Otology, Hearing, and Speech

While on the faculty at Johns Hopkins, Harvey Cushing forged a strong and lasting mentor relationship with Samuel J. Crowe. This relationship continued after Cushing left to become professor of surgery at Harvard University in 1912. Cushing had made several visits to Switzerland, where he developed a friendship with Felix Robert Nager, the first chair of the Department of Otolaryngology at the University of Zurich, with whom he shared an interest in the pituitary gland (Tissli Nager, written and oral communication, 2013; Donlin Long, personal communications). Crowe subsequently visited Nager's department while working in Europe as a consultant to the U.S. Army during World War I, which led to a formative clinical and research experience that influenced the remainder of his career. In particular, Crowe's exposure to Felix Robert Nager's temporal bone collection left a lasting impression.

In 1924, Crowe established the Otological Research Laboratory, the first temporal bone collection in the United States, with financial support from the General Educational Board of the Rockefeller Foundation.⁸ With the recent development and manufacture of the first reliable audiometer, the Western Electric 100 by Fowler and Wengel in 1922^{9,10} (Fig. 15), Crowe had a vision of correlating auditory function with pathology of the middle and inner ear from histological sections. Crowe invited Stacy R. Guild (Figs. 8 and 16), formerly an associate professor of anatomy at the University of Michigan, to Johns Hopkins as the laboratory director.

As director of the Otological Research Laboratory, Guild developed the technique for reconstruction of cochlear sections that has had a profound and lasting impact on hearing research.¹¹ Efforts to correlate cochlear anatomy with hearing function in temporal bone donors was subsequently possible, leading to the first demonstration of pathologic changes related to age-related hearing loss.¹² Furthermore, a commitment to the clinical measurement of hearing in patients who might become potential future temporal bone donors contributed to the evolution of clinical audiology, aided by such innovators as Cornelius C. Bunch, considered one of the forbears of the field and author of the first manual on audiometry.^{13,14} His influence and impact is reflected by the list of prominent clinicians and scientists who were known to visit the department to learn from Guild, including John Lindsey from the University of Chicago, Charles Hallpike from Queen Square in London, Meryl Lawrence from Princeton, and E. Glen Wever, also of Princeton,

who discovered cochlear potentials (unpublished interview of John E. Bordley by Michael M.E. Johns, 1986).

The confluence of new developments in temporal bone analysis and clinical audiology led Crowe, Guild, and others to correlate, for the first time, the loss of high-frequency hearing in older adults and the atrophy of hair cells in the basal turn of the cochlea.^{12,15} Built on this foundational work were the contributions of John E. Bordley; Edward M. Walzl, a graduate student in physiology; and Clinton Woolsey, the renowned Johns Hopkins neurophysiologist and Walzl's supervisor, who further delineated the frequency-place relationships of the auditory nervous system by examining electrophysiological responses to known cochlear lesions in animal models.^{16–18} Guild was also the first to discover and describe glomus bodies within the adventitia of the jugular bulb¹⁹—and along the course of the tympanic branches of the ninth and tenth cranial nerves,^{19,20} the sites of origin of glomus jugulare and tympanicum tumors, respectively.^{21,22}

The Otological Research Laboratory greatly contributed to the understanding of early-onset hearing loss in children. From 1924 to 1938, hearing examinations made on approximately 15,000 patients demonstrated that high-tone hearing impairment, measured using tones delivered by air conduction, was not limited to older adults but also occurred in children. Histological data in temporal bone specimens demonstrated middle ear pathology in several pediatric cases, debunking the widely accepted theory that high-tone hearing impairment was always caused by a primary inner ear or nerve lesion. Donald F. Proctor, a resident and then faculty member during Crowe's tenure as director, recalls the confluence of skills and technology that led to these developments⁸:

Crowe's superbly logical mind and his skillful hands made use of the electric nasopharyngoscope and otoscope, as well as the facilities of his otologic research laboratory (including the first effective audiometer), to note the association between recurring adenoids, serous otitis, and childhood deafness.

Although not the first to describe this relationship, Crowe's empiric studies further solidified these ideas and led to efforts at early identification, treatment, and prevention.

Crowe's awareness of a 1905 article²³ describing the susceptibility of lymphoid tissue to irradiation led him to propose and pursue this treatment modality as a strategy for limiting barotrauma due to Eustachian tube obstruction in fighter pilots and submariners in World War II²⁴ (Lee Williams, personal communication, 2013), and for preventing and ameliorating childhood hearing loss due to otitis media.⁷ This treatment involved the transnasal placement of a radium applicator in the nasopharynx for short time intervals (Fig. 17).²⁶⁵

In 1942, Guild and Donald F. were approached by the Washington County Health Department in Hagerstown, Maryland, to conduct a hearing and speech conservation program with school-age children. This effort, which eventually included all Maryland counties, was one of the first population-based hearing-screening programs in children.⁸ Of 7,615 children screened between 1944 and 1947, 4.6 percent were referred to Johns Hopkins, and fewer than half received radium treatments. Although local radium irradiation

of the nasopharyngeal lymphoid tissue obstruction of the Eustachian tubes produced favorable hearing results,²⁵ increasing concern about the potential induction of malignant tumors by this method rendered this an unacceptable treatment by the 1960s, and it was subsequently replaced by myringotomy and grommets or pressure equalization tubes placed in the ear drum. Subsequent follow-up has not demonstrated an increased incidence of malignancies or other disorders in irradiated Johns Hopkins patients.²⁶ Other series, however, have revealed an increased rate of malignancies.²⁷

In 1950, Guild presented data showing that there was no positive effect from the radium treatment that these patients received. He stated:

The broad conclusion is reached (from the data in the paper) that the previous ideas, widely prevalent, of the effect of nasopharyngeal lymphoid tissue on hearing and of the effect of nasopharyngeal irradiation on impaired hearing, need to be revised.²⁸

Guild's disagreement with Crowe regarding the use of radium treatment of the adenoids in the management of otitis media led to Guild's marginalization, including the loss of his laboratory until reestablished by John E. Bordley in 1955 (Fig. 18).

Inspired by Guild's work, George T. Nager devoted his career to continuing the legacy of careful histopathologic study of the temporal bone at Johns Hopkins. He continued to expand the collection that Samuel J. Crowe had been motivated to start after seeing the elder Nager's collection at the University of Zurich. Among Nager's contributions to the understanding of otological disease was his careful description of the bony changes that lead to conductive and sensorineural hearing loss due to otosclerosis. He described the invasive potential of otosclerotic foci and the enhanced vasculature that supports it.^{29,30} By studying a pair of identical twins who developed clinical otosclerosis later on in their lives in almost identical fashions, Nager was able to demonstrate that genetics play an important role in otosclerosis, much more so than environmental factors.³¹ He was one of the first to demonstrate the pathologic correlates of sensorineural hearing loss associated with cochlear otosclerosis,³² including atrophy and hyalinization of the spiral ligament.²¹ Nager described the distribution of meningiomas in the temporal bone, proposing that they may arise from ectopic arachnoid villi.^{21,33,34} Other important contributions included characterization of the middle ear blood supply³⁰ and the histopathologic manifestations of bone dysplasias, including Paget's disease³⁵ and osteogenesis imperfecta.³⁶ Nager presented his large body of work in *Pathology of the Ear and Temporal Bone*, one of the definitive texts in temporal bone histopathology.²¹

Hearing and Speech

Audiology at Johns Hopkins started in 1927 with the appointment of Cornelius C. Bunch as associate professor of otology and otolaryngology. Bunch is recognized as one of the first clinical audiologists in the United States and the founder of clinical audiometry, likely influenced by extensive clinical experience using one of the world's first audiometers in his work with Crowe and Guild in the Otological Research Laboratory.^{13,14} The department established the Hearing and Speech Center in 1947, one of the first such clinics in the United

States. It committed itself to the early diagnosis of and intervention for hearing loss in children, producing approaches and protocols that continue to influence the field today. Under the departmental leadership of Samuel J. Crowe, John E. Bordley, and George T. Nager, the center served as a model for the interdisciplinary management of childhood hearing disorders and was one of the first such clinics associated with an academic department and hospital. The Hearing and Speech Center was led by William G. Hardy with the assistance of Mir-iam Dorothy Pauls (Figs. 19 and 20), both audiologists and speech pathologists who were married soon after arriving at Johns Hopkins.³⁷

Formative professional experiences that laid the foundation for their landmark work at Johns Hopkins included Pauls' employment in special education and aural rehabilitation as a teacher of the deaf. Hardy, Pauls, and Harriett Haskins, who also joined their team at Johns Hopkins, were all part of the military's post-World War II effort to provide hearing aids to newly returned veterans at the U.S. Navy Hospital in Philadelphia using newly available transistor hearing aids. The founding staff of the Hearing and Speech Center applied these unique skills and experiences to the nascent field of pediatric hearing rehabilitation, with a strong emphasis on early diagnosis and intervention. This was among the first such hospital-based programs in the United States and was further distinguished by its commitment to discovery, innovation, and multidisciplinary care. Young children were fitted with early-generation high-powered amplification, which was used to facilitate aural and speech therapy designed to promote the development of spoken language (unknown, 1950).²⁶⁶

A keystone to their strategy, the objective identification and measurement of hearing loss in young children, was made possible by a Johns Hopkins innovation that detected skin responses to sound perception.³⁸ This new psychogalvanic skin-resistance response test was introduced by a Johns Hopkins psychologist, Curt Richter, and required that the child be first conditioned to anticipate a light shock in response to hearing a pure tone.^{38,39} Activation of the sweat glands by the sympathetic nervous system reduced skin resistance, which was detected and indicated that the tone was heard. Bordley and Hardy applied this new technique to young children, making it possible for the first time to consistently measure pure tone thresholds, which were used as the basis for early diagnosis, amplification, and rehabilitation of speech and language.

The combined efforts of the Hardys, Bordley, and their colleagues in the Hearing and Speech Center established the clinical philosophies and interdisciplinary practice that form the foundation of today's practice. As was described in 1951,^{40,41}

A means for accurate testing of the hearing of infants and young children under 4 years of age has long been sought. It is needed for differential diagnosis by the pediatrician, the otologist and the psychiatrist, and as a basis for clinical procedures and educative guidance by the audiologist and the teacher. Somewhere in the middle, in terms of needs, is the parent, whose behavior, attitudes, and beliefs about a child's normalcy or abnormalcy are usually important determinants of his welfare and happiness.

Subsequently, their efforts extended beyond the walls of The Johns Hopkins Hospital to support of families and educators.⁴² Along with Bordley, the Hearing and Speech Center

also established the Division of Audiology and Speech at the Johns Hopkins School of Hygiene and Public Health to fulfill the education and research components of their mission. Several leaders in the field of audiology received training in this program and contributed to its scholarship, including Charles Berlin, PhD, founder of the Kresge Institute at Tulane University in New Orleans. Other national luminaries who trained at this time included Patrick Brookhouser, who established the Boys Town National Research Hospital in Omaha, Nebraska, in 1972 to advance the treatment of communication disorders in children, very much in the image of the Hearing and Speech Center; and Fred H. Linthicum Jr., MD, one of the founding members of the Otologic Medical Group in Los Angeles in 1956, and also founding director of the temporal bone collection within the House Ear Institute.

Additional advances in the application of neurophysiological methods to audiology were accomplished in this period of multidisciplinary collaboration. As part of a larger body of work examining the basic mechanisms of hearing (see section on History of Basic Science Research in Hearing and Balance at Johns Hopkins), Robert Ruben's leadership of the division's Neurophysiology Laboratory (1958–1964) led to the first convincing and reproducible description of the cochlear microphonic in humans.⁴³ This work established a new era in the application of electrophysiology to clinical diagnosis of hearing function. Ruben subsequently became the chair at Albert Einstein College of Medicine of Yeshiva University (1970–1998) and a national leader in pediatric otolaryngology and communication disorders.

Pioneering work of Hiroshi Shimizu (Fig. 21) in the 1960s to early 1980s also included some of the earliest applications of the auditory brain stem response to tumor diagnosis and neonatal hearing evaluations, and the description of the steady-state evoked potential. In the late 1950s, Shimizu came to Johns Hopkins as a fellow from the Kyoto Prefectural University, Japan.⁴⁴ After returning to the faculty there, he was recruited back to Baltimore in 1963, where he would spend the next 30 years as director of the Hearing and Speech Center at Johns Hopkins through 1991. Shimizu's primary contribution was the application of electrophysiological principles and techniques to the diagnosis of auditory disorders in patients.^{45,46} Shimizu was the first to demonstrate changes in the morphology and latency of auditory brainstem responses associated with tumors of the cerebellopontine angle, making this a valuable screening test for these lesions.⁴⁷ Starting in the 1960s, he used the ABR to evaluate newborns for hearing loss, making him one of the first to do so.

Neurotology and Skull Base Surgery

George T. Nager was part of the vanguard of modern otology and neurotology, establishing a tradition of surgical collaboration between OHNS and Neurosurgery at The Johns Hopkins Hospital. With the arrival of Donlin Long as director of neurosurgery in 1973, this collaboration was pursued in earnest, starting with joint work between both directors in transsphenoidal and acoustic neuroma surgeries. Nager hired Michael Holliday in 1976 following his residency at Johns Hopkins and a fellowship with Ugo Fisch at the University of Zurich. Holliday developed this multidisciplinary skull base program and became one of the world's most prolific skull base surgeons. The prominence of the department as a center of excellence in neurotology was furthered through the leadership of Douglas Mattox, who

also trained with Ugo Fisch, and subsequently John K. Niparko, who trained with Malcolm Graham and John Kemink at the University of Michigan.

As chief of the Division of Otolaryngology and Neurotology from 1991 to 2012, Niparko oversaw the growth of the division faculty from three to 10 members. The Johns Hopkins Neurotology Fellowship was begun with Martin Burton of Oxford University, now the director of the International Cochrane Collaboration, as the program's first fellow. This expanded clinical and basic science research contributed to a rapid growth in scholarly and clinical productivity of the division. The division also became the editorial home for the specialty's leading journal, *Otology & Neurotology*.

As founder and director of the Listening Center, the Johns Hopkins cochlear implant program, Niparko continued the Johns Hopkins legacy of advancing new technologies and multidisciplinary care. The Listening Center created a medical model to include auditory and speech rehabilitation with early education in expanding the options for families with deaf children. The collective work of the Listening Center in advocating for improved access to cochlear implant technologies and mainstream educational opportunities called for multidisciplinary outcomes assessment^{48,49} and elevated the division to the national and international forefront of the field.

By applying the concepts of cost utility to cochlear implant intervention, The Listening Center has led the way in the research of outcomes associated with hearing rehabilitation and demonstrated the value of the cochlear implant intervention at all ages in landmark publications.^{50–54}

The Johns Hopkins Listening Center served as the principal investigative site of the first prospective study of language and other outcomes in children with cochlear implants, the Childhood Development after cochlear Implantation (CDaCI).⁵⁵ This NIH-funded multicenter investigation promises to influence the field for years to come. For example, the CDaCI study has confirmed the importance of early intervention and revealed the critical contributions of implant timing, parental interaction, socioeconomic status, and epigenetic expression⁵⁶ on hearing and language outcomes.^{54,57} Niparko also continued the tradition of clinician scientist collaboration in the auditory sciences through groundbreaking and widely quoted work conducted with Ryugo elucidating mechanisms of hearing loss and the biology underlying rehabilitation in deaf white cats.^{58,59} More recently, a team led by Niparko and Bradford May demonstrated the ability of integrated bone conduction hearing aids to mitigate the informational masking constraints imposed by acquired single-sided deafness.⁶⁰

Vestibular Program

The development of vestibular research and clinical programs started under George T. Nager's leadership with the recruitment of Leonard Proctor in 1976.

In 1976, Leonard Proctor started work on developing a modern vestibular laboratory in which he integrated innovations in caloric stimulation methods and computer-based analysis of eye movements or nystagmus to produce an efficient and automated system for use in routine clinical care and research. For the first time in the field, the Johns Hopkins

Vestibular Laboratory brought into routine clinical use a new caloric irrigation method that Proctor had participated in developing at the University of Chicago.⁶¹ It employed a procedure in which the durations of hot and cold irrigation pulses were precisely timed based on known heat transmission characteristics of the temporal bone. Compared to the traditional Fitzgerald–Hallpike technique, this new Proctor–Dix method was more reproducible, required less time, caused less patient discomfort, and produced comparable results.⁶² With the help of Robert Glackin's programming abilities, a new interactive computer program was also developed to facilitate the recording and immediate analysis of nystagmus in response to caloric stimulation. Reference values for normal vestibular function were determined using this system and remain relevant to routine clinical practice today.⁶³ Proctor's laboratory and clinical studies of the effects of ototoxic medications, including aminoglycoside antibiotics, on vestibular function paved the way for the therapeutic use of these medications in Ménière's disease.⁶⁴

An increasing emphasis on vestibular sciences and comprehensive care occurred in the early 1980s with close collaboration across otology (Leonard Proctor, Douglas Mattox, and Michael Holliday), audiology (Hiroshi Shimizu and Craig Formby), neurology (David Zee, Timothy Hain, and Ronald Tusa), and physical medicine and rehabilitation (Susan Herdman). Regular interdisciplinary patient conferences were started and remain a critical component of the clinical, research, and teaching missions of the division.

The recruitment of Lloyd B. Minor by Charles W. Cummings in 1993 subsequently led to a period of unprecedented discovery and advances in clinical treatment of vestibular disorders by the unparalleled efforts of Minor, his mentees (including David Lasker, John Carey, Richard Clendaniel, Phillip Cremer, Charles Delia Santina, Timothy Hullar, Michael Schubert, Americo Migliaccio, Benjamin Crane, and Yuri Agrawal), and his collaborator and mentor in neurology, David Zee.

Working with Jay Goldberg and colleagues, Minor helped characterize the neural pathways mediating the vestibuloocular reflex in squirrel monkeys through a combination of anatomic and neurophysiologic studies.^{65–67} Upon his arrival at Johns Hopkins, Minor established the Laboratory of Vestibular Neurophysiology with the goal of bringing a bench-to-bedside translational research approach to the evaluation and management of patients with Ménière's disease and other vestibular disorders—a field relatively neglected among otolaryngologists at the time—while training a new generation of surgeon scientists dedicated in equal parts to basic science, applied science, and clinical care. Aided in this pursuit by strong and lasting collaborations with David Zee; David Robinson; and others in the Oculomotor Neurophysiology Laboratory within the Johns Hopkins' departments of neurology and biomedical engineering, as well as Kathleen Cullen at McGill University, Minor and members of his laboratory went on to publish more than 100 studies of vestibular physiology, anatomy, and clinical care. These studies helped to clarify the prognosis of bilateral ototoxic injury due to gentamicin⁶⁸ and the optimal treatment protocols for use of intratympanic gentamicin in the treatment of Ménière's disease.^{69,70} This body of work also addressed the dynamics of the vestibuloocular reflex and neural pathways underlying its fast responses and plasticity.^{71–79} After making one of the most important clinical discoveries in modern otology, Minor and colleagues carefully studied and described the pathophysiology

and surgical management of superior canal dehiscence syndrome.^{80–95} The importance of this discovery has led many to propose renaming this condition, characterized by noise- and/or pressure-induced vertigo and increased bone conduction sensitivity of the cochlea—all related to a third labyrinthine window created by dehiscence of the superior semicircular canal—as *Minor's syndrome*.

John Carey continued to build the division's reputation as an international referral center for superior canal dehiscence syndrome by refining both the temporal bone anatomy⁸⁷ (Fig. 22) and the appropriate radiologic^{90,92} and physiologic evaluation^{96,97} for the disorder. In a series of studies of the effects of intratympanic gentamicin, Carey and colleagues correlated the structural and neurophysiological changes in the labyrinth of the chinchilla with findings from patients treated with intratympanic gentamicin for intractable vertigo due to Ménière's disease. They demonstrated that gentamicin likely creates a partial lesion, being taken up by and particularly toxic to the type I vestibular hair cell, yet having little effect on the vestibular nerve afferents.^{98,99} This demonstrated an advantage over the complete deaf-ferentation associated with labyrinthectomy or sectioning of the vestibular nerve because the partial lesion would present less burden to the compensatory mechanisms of the central nervous system.

A biomedical engineer, cochlear implant surgeon, and neurotologist with a special interest in the study and treatment of vestibular disorders, Charles Delia Santina founded the Johns Hopkins Vestibular Neuro-Engineering Laboratory (VNEL) in 2002 and focused the group's efforts on developing a vestibular implant, as well as other new technologies for diagnosis and treatment of vestibular disorders. Expanding on previous work by others,¹⁰⁰ Delia Santina and his colleagues developed the world's first multichannel vestibular prosthesis (MVP) for restoration of head motion sensation.^{101,102} This work was significantly facilitated by the development of a new method of video-oculography developed by former VNEL member Americo Migliaccio, who went on to found a leading laboratory devoted to oculomotor physiology,^{103–105} as well as current VNEL faculty Gene Y. Fridman¹⁰⁶ and Chenkai Dai.¹⁰⁷ The MVP is now under review by the U.S. Food and Drug Administration (FDA) for use in humans.

Susan Herdman, who joined the department in 1987, was one of a handful of academic physical therapists at the time to begin conducting clinical outcomes research into the benefits of vestibular rehabilitation. Her textbook, *Vestibular Rehabilitation*,¹⁰⁸ is considered the preeminent text on the topic. Richard Clendaniel completed his postdoctoral fellowship with Herdman and in 1997 joined the faculty. His research efforts characterized unique aspects of contextual learning within the vestibuloocular reflex.¹⁰⁹ Clendaniel moved to Duke University as Michael Schubert was completing his postdoctoral fellowship in the Minor laboratory before joining the faculty in 2004. Schubert's research established a critical component in vestibular rehabilitation—that the brain includes neural circuitry for one-sided motor learning within the vestibular systems.¹¹⁰ This is enabling a more focused type of rehabilitation for patients with injury to their inner ear. Current collaborative work with Migliaccio has led to the development of a medical rehabilitation device.¹¹¹

Faculty within the division continue to provide international leadership in sophisticated research methodologies applied to skull base surgery, cochlear implantation, vestibular function, and translational research. New fields of study and practice are emerging, including the work by Charles Limb to characterize the neuroscience of music perception and its applications to the advancement of prosthetic hearing.¹¹² The aging of the United States and growing emphasis on health outcomes calls for a multidisciplinary and population-based approach to the negative consequences of hearing loss and falls. Frank Lin has identified critical links between age-related hearing loss and general health and functional outcomes in older adults. The public health and economic relevance of these discoveries have highlighted the potential importance of hearing rehabilitation in averting cognitive declines and premature morbidity and mortality in aging.¹¹³ Yuri Agrawal and John Carey have established multiinstitutional and interdisciplinary studies and intervention trials to address vestibular dysfunction and fall risks in the aging population.¹¹⁴ The division therefore continues to serve as a fertile ground for innovation and training of the next generation of academic leaders.

Numerous advances in otolaryngology have arisen from the strong and long-standing collaboration between otology/neurotology faculty and the Laboratory of Oculomotor Neurology, initially led by David Robinson (inventor of the scleral coil technique of eye movement measurement and one of the founders of biomedical engineering¹¹⁵) and currently led by David S. Zee (world-leading oculomotor neurologist and coauthor of the definitive text on oculomotor neurology, *The Neurology of Eye Movements*).¹¹⁶ In addition to making significant contributions to the discovery and characterization of superior canal dehiscence syndrome and the characterization of vestibuloocular reflex function after labyrinthine injury, Zee and colleague Dale Roberts led the group that initially described magnetohydrodynamic vestibular stimulation, by which the strong magnetic fields of magnetic resonance imaging (MRI) machines elicit nystagmus and vertigo through direct action on hair cells.¹¹⁷ The group's ongoing studies of this effect, notably accelerated by Bryan K. Ward,^{118,119} comprise the founding canon of literature for an entirely new field of research, with great potential impact for functional imaging and use of high-field MRI in clinical care.

History of Basic Science Research in Hearing and Balance at Johns Hopkins

In the 1940s, Edward M. Walzl (Fig. 23), John E. Bordley, and Clinton Woolsey contributed to the delineation of the frequency-place relationships of the auditory nervous system by examining electrophysiological responses to known cochlear lesions in cats.^{120–122} This tradition of research in auditory physiology at Johns Hopkins was continued by Robert J. Ruben between 1958 and 1964 while he was a resident. Aware of his previous work with E.G. Weaver at Princeton University on electrophysiology in the auditory system, Bordley asked Ruben, while he was still a medical student, to become the principal investigator on an NIH grant in the department.

Ruben's laboratory (Fig. 24) conducted important work on hearing physiology in mice, which laid the foundation for establishing this now ubiquitous animal model for hearing

research.^{123–128} Other contributions included the further elucidation of hearing physiology in animal models, including inhibitory responses in the central auditory pathway.¹²⁹ Careful studies of cochlear potentials characterized the microphonic response in man (Fig. 25).^{43,130–133}

Several fellows in the laboratory (Fig. 24) went on to leadership positions as clinicians and researchers, including Bobby Alford (1961, Johns Hopkins fellowship; Chairman of OHNS and dean at Baylor University), Ugo Fisch (1960, Johns Hopkins fellowship; Chairman of Otolaryngology, University of Zurich, Switzerland), William Hudson (1960, Johns Hopkins fellowship; Chief of Otolaryngology, Duke University), Jan Sekula (1959 Johns Hopkins fellowship; Chairman, Jagiellonian University in Krakow, Poland), and Armando Chiang (1961, Johns Hopkins fellowship; Chairman of OHNS, University of Santo Tomas, Manila, Philippines). Ruben completed residency in 1964 and then went to the NIH as a research associate for 2 years. He returned to New York as an assistant professor at New York University from 1966 to 1968 and then became chair of otolaryngology in the Albert Einstein College of Medicine of Yeshiva University from 1968 to 1998.

Hearing research in the Department of OHNS cannot be described without also mentioning the influence of early investigators in other departments, including the departments of biomedical and electrical engineering. In parallel with the groundbreaking research of David Hubel and Torsten Weisel in vision and Vernon Mountcastle in somatosensation, Moise Goldstein and Moshe Abeles founded the Neural Encoding Laboratory as a center for auditory research at Johns Hopkins in 1963. Goldstein's work on cortical processing in behaving macaques revealed the importance of attention on cortical tuning and the tonotopic organization of the awake brain.¹³⁴

Partnerships with Biomedical Engineering and Neurology: The Center for Hearing and Balance

The Center for Hearing Sciences was established in 1985 as a collaboration between the departments of OHNS and neurology in the School of Medicine and the Department of Biomedical Engineering in the School of Engineering. The center provided a rich intellectual environment for shaping the future growth of hearing research and research training at Johns Hopkins. In 1991, the Center for Hearing Sciences became the Center for Hearing and Balance to reflect the increased emphasis on vestibular research within otolaryngology, biomedical engineering, and neurology.

As director of the new Department of Biomedical Engineering, Murray Sachs (Fig. 26) built a world-class hearing research group that joined with the departments of otolaryngology and neurology to establish the Center for Hearing Sciences. Sachs joined the Department of Biomedical Engineering in 1970 after completing a PhD at the Massachusetts Institute of Technology and a postdoctoral fellowship at Cambridge University. In contrast to Moise Goldstein's attempts to link higher cognitive functions to cortical physiology, Sachs' research reflected a bottom-up engineering approach. The auditory nerve was ideal for these studies because the discharge rates of individual nerve fibers could be linked directly to the physical characteristics of sound. During two decades of research at Johns Hopkins, Sachs

made key discoveries on how the neural representation of auditory information is influenced by sound level, background noise, and hearing loss.^{120–122}

Following graduate studies under the direction of Sachs and postdoctoral work at the University of Chicago, Eric Young joined the biomedical engineering faculty in 1975. Continued collaboration with Sachs yielded critical findings in the neural coding of speech in the auditory nerve.^{135,136} In subsequent research, Young and other members of the Center for Hearing Sciences carefully described how the unique spectral integration properties of the dorsal cochlear nucleus are essential for directional hearing.¹³⁷

While on the faculty of the University of Florida, William E. Brownell made one of the most fundamental observations of inner ear biology: outer hair cells move when stimulated with electrical currents.¹³⁸ This property of electromotility explains the exquisite sensitivity and tuning of the mammalian cochlea. Soon after this discovery, Brownell was recruited to serve as the director of research in otolaryngology at Johns Hopkins. Much of his research efforts at Johns Hopkins until his departure to Baylor University in 1994 (www.bcm.edu/departments/otolaryngology/about-us/hall-of-fame/william-e-brownell) were directed toward understanding the cellular mechanisms of electromotility.^{139,140}

Paul Manis, who earned his PhD under the supervision of Brownell at the University of Florida, was recruited by Brownell and Michael M.E. Johns in 1985. Manis used in vitro electrophysiological techniques to study basic mechanisms of neural plasticity in the auditory system, including long-term potentiation and depression in the dorsal cochlear nucleus. This work resulted in a model system for understanding somatosensory inputs to the auditory system and the pathogenic plasticity that leads to tinnitus.^{141–143}

David Ryugo joined the department in 1987 to complement existing physiological strengths with functional anatomy. In particular, Ryugo provided a strong basic science foundation for studying the impact of hearing loss on the structure and function of the ventral cochlear nucleus.^{144–146} His close collaboration with John Niparko yielded seminal observations of how electrical stimulation by the cochlear prosthesis reverses some structural features in the auditory brainstem that are induced by hearing deprivation.¹⁴⁷ Ryugo collaborated extensively with clinical investigators in the department and provided critical research training to several residents and young clinical faculty. He became the department's director of research in 1991 and retired from Johns Hopkins in 2010.

Brad May joined the department in 1990 after completing his PhD at the University of Michigan and a postdoctoral fellowship at Johns Hopkins with Sachs. His research brought an animal behavioral perspective to studies of sound processing in the cochlear nuclei. His lesioning studies linked the dorsal cochlear nucleus to monaural sound localization cues and the olivocochlear efferent system- to activity-based synaptic development in the ventral cochlear nucleus. His present research focuses on the neural correlates of tinnitus in the cochlear nucleus and inferior colliculus¹⁴⁸ and the development of novel clinical cognitive measures of listening in competing noise or informational masking.¹⁴⁹

As a resident, neurotology fellow, and then faculty member in the department, Howard Francis worked with Manis to elucidate the effects of hearing deprivation on the intrinsic

electrophysiological properties of ventral cochlear nucleus cells.¹⁵⁰ Building on previous ultrastructural studies of cochlear innervation at the Massachusetts Eye and Ear Infirmary with Joseph B. Nadol Jr., chair of the Department of Otolaryngology, Francis later collaborated with Ryugo to characterize the innervation of the mouse cochlea. Changes in afferent and efferent innervation and synaptic morphology at inner hair cells were described for the first time in association with age-related hearing loss.^{151,152} This collaboration also led to the development of a definitive frequency map of the murine cochlea and auditory brainstem.¹⁵³

Paul Fuchs was recruited to the Center for Hearing and Balance in 1995 from his position in physiology at the University of Colorado School of Medicine, Aurora. He brought a new focus on cellular physiology of the inner ear.^{154,155} His lab, in collaboration with A.B. Elgoyhen, established the molecular mechanisms by which efferent neurons inhibit cochlear hair cells.¹⁵⁶

Upon completing her PhD at the Georg-August University in Göttingen, Germany (www.hopkinsmedicine.org/promes/results/directory/profile/778621/elisabeth-glowatzki), Elisabeth Glowatzki joined Fuchs' laboratory in 1998 as a research fellow. Her arrival began a series of fundamental discoveries on afferent synaptic signaling and established in vitro recordings of afferent and efferent synaptic activity in the mammalian cochlea. Glowatzki and Fuchs provided an initial description of the unusual properties of the ribbon synapse between cochlear inner hair cells and auditory nerve fibers.¹⁵⁷ Most recently, this partnership has provided the first insights into the functional role of previously mysterious type n cochlear afferents.¹⁵⁸

As previously outlined, Lloyd B. Minor's enduring legacy includes a number of fundamental findings about the nature of signal processing in the vestibular system, particularly as to how the nonlinear responses of some vestibular afferents relate to changes in vestibular reflexes after loss of unilateral vestibular function. Despite Minor's transition from laboratory director to department director (in 2003), The Johns Hopkins University provost (in 2009), and dean of the Stanford School of Medicine (in 2012), the group he founded continues to expand the boundaries of vestibular science and clinical management (see section on the Vestibular Program for more details).

History of Airway Endoscopy and Surgery at Johns Hopkins

Even before the formation of the Division of Otolaryngology at Johns Hopkins, there was an active laryngology community in Baltimore. As the department grew under the guidance of Samuel J. Crowe, it became internationally recognized for contributions made in endoscopy and head and neck pathologies due to work done by Edwin N. Broyles in furthering our understanding of laryngeal cancer, and Bernard Marsh and Haskins Kashima in developing new diagnostic paradigms using fiber optic endoscopy to treat airway disease.

Beginning of Airway Endoscopy and Laryngology in Baltimore

John N. Mackenzie was one of the founders of the Baltimore Eye, Ear, and Throat Charity Hospital. In 1887, he was called to the chair of Laryngology and Rhinology at the University

of Maryland School of Medicine. He described the quarters assigned to him in the dispensary, where patients were examined as,

[A] little compartment or 'box' from which all sunlight and fresh air were carefully excluded, and in whose foul atmosphere two of my assistants subsequently probably contracted tuberculosis. It was thus thoroughly equipped and under such cheerful conditions that, without either moral or financial support on the part of the executive branch of the institution, I began the task of teaching practical laryngoscopy to undergraduate students.¹⁵⁹

Two years later, Mackenzie was appointed clinical professor of laryngology in the Johns Hopkins University School of Medicine and member of staff of The Johns Hopkins Hospital, which had just opened its doors in 1889.² He had great interest in teaching, and in 1901 he pointed out that the study of laryngology had been grossly neglected in the medical schools of this country and Europe.

When the Johns Hopkins University School of Medicine formally opened in 1893, it became the first institution of higher learning in the world to require the study of laryngology for the degree of doctor of medicine. Mackenzie served as president of the American Laryngological Association (ALA) in 1889 and worked at Johns Hopkins until 1912.

At the time of Crowe's appointment as director in 1912, Mackenzie and others working in the dispensary took offense and promptly discontinued their attendance, leaving Crowe as the sole member of the division and forcing him to rebuild the division from the ground up. William S. Halsted seemed impervious to the reaction to Crowe's appointment. He suggested that otolaryngology also include diseases of the thorax and said Crowe could go abroad from time to time for study. The following year, Crowe and Harry Slack, an assistant and recent Johns Hopkins School of Medicine graduate, spent the summer in Germany with Gustav Killian, who was later recognized as the "father of bronchoscopy."

Edwin N. Broyles (Figs. 27 and 28) was a 1919 graduate of the Johns Hopkins School of Medicine who completed his otolaryngology residency in 1922 at Johns Hopkins. He was one of Crowe's first hires for the growing department and began his leadership of the Endoscopic and Bronchoscopic Clinic in 1923. Broyles had a prominent role throughout his career in the professional societies, serving as president of the American Broncho-Esophageal Association (ABEA) in 1953 and as president of the ALA in 1960 to 1961.

Together with Crowe, Broyles designed a modification of the total laryngectomy procedure to treat patients with advanced laryngeal cancer.¹⁶⁰ His analysis of the whole organ mounts from these surgical specimens led to his work on the anterior commissure confluence (Broyles' ligament) that bears his name.¹⁶¹ This work was an elegant demonstration of vocal fold anatomy and its relevance to the treatment of laryngeal cancer. His words from his original report have had a lasting impact on the subsequent development of partial laryngectomy techniques:

In those cases of carcinoma of the larynx where the growth has invaded the tendon and perhaps the cartilage, it would seem advisable to either perform a laryngectomy or remove the midportion of the thyroid cartilage along with the diseased cord.

In the 1930s, Broyles worked with his close friend and surgical colleague William Reinhoff on a variety of thoracic, bronchial, and tracheal procedures.¹⁶² This work prompted the need for improved diagnostic technology, which led to his innovation of the telescopic bronchoscope in 1940 to illumine and magnify airway structures in the field of vision. Broyles is also acknowledged for introducing the optical forceps in 1948 and fiber illumination for the rigid bronchoscope in 1962.¹⁶³ These new instruments aided in the visualization of the upper lobe bronchi and lower lobe segments, areas that were previously very difficult to examine.

In recognition of his contributions as a teacher and physician, the Johns Hopkins Bronchoscopic Clinic was named in Broyles' honor upon his retirement in 1963, and his contributions to bronchoesophagology were recognized by his receiving the Chevalier Jackson Award in 1963 from the ABEA and the Newcomb Award from the ALA in 1965.

Other contributions to the understanding of laryngeal anatomy and tumor spread resulted from the application of Stacy R. Guild's techniques of temporal bone sectioning and analysis to the larynx. One of Crowe's previous residents, Gabriel Tucker, applied Guild's technique to the larynx while a faculty member.¹⁶⁴ His work and that of John Kirchner,¹⁶⁵ another Crowe resident and chief of otolaryngology at Yale, rapidly advanced the characterization of tumor extension pathways within and beyond the larynx. These contributions have subsequently informed diagnostic, staging, and surgical approaches in the management of laryngeal cancer.

The Johns Hopkins Bronchoscopic Clinic

The Broyles Bronchoscopic Clinic distinguished itself through a number of innovations to the rigid bronchoscope and by popularizing the use of the flexible fiber scope. In the 1930s and 1940s, Broyles introduced a series of proximal magnifiers, lenses, and defogging devices for rigid bronchoscopy, as well as the first fiber-illuminated bronchoscope.^{166–168}

A decade later, Shigeto Ikeda of Keio University School of Medicine, Japan brought the flexible fiber bronchoscope manufactured in collaboration with Machida Endoscope Co. Ltd., to Johns Hopkins, where Bernard Marsh popularized its use.

After completing his training at Johns Hopkins under John E. Bordley, Marsh joined the part-time faculty and served as director of the Broyles Bronchoscopic Clinic beginning in 1968, joining the full-time faculty in 1982. The addition of the fiberscope to the bronchologists' armamentarium allowed the Johns Hopkins otolaryngology team to play a key role in localizing tumors for the Johns Hopkins Lung Project. With significant input from Marsh, this project, conducted between 1968 and 1982, studied over 10,000 high-risk volunteers to assess whether the addition of cytology screening to chest radiograph utilization could improve early detection of asymptomatic lung cancer and whether early therapy could significantly reduce associated mortality.¹⁶⁹ To augment sputum cytology, the bronchoscopic clinic offered flexible bronchoscopy of the bronchial tree to provide brushings and biopsies by lung segment. The department maintained a leadership role in bronchoesophagology. In recognition of his expertise, Marsh was elected president of the ABEA in 1982.

Otolaryngologists in the Broyles Bronchoscopic clinic collaborated with Pilling, Inc., to design instruments and produced the first adaptor to allow flexible bronchoscopy through an endotracheal tube while ventilating. Courses at the clinic included monthly animal laboratory sessions to practice foreign body removal and intubation techniques with the fiberoptic bronchoscope. Additional courses hosted national and international physicians and taught physiology, pathology, diagnostics, and therapeutic techniques associated with airway and esophageal disease. By the 1990s, with otolaryngologists focusing on foreign body removal, the field of diagnostic and therapeutic bronchoscopy became the purview of pulmonary medicine.

Another major figure in the history of Johns Hopkins Laryngology was Haskins “Chuck” Kashima (Fig. 29), who spent the majority of his 30-year career at Johns Hopkins, starting in 1970. He was particularly known for his contributions in human papilloma virus (HPV) research and novel surgical treatments for laryngeal disease.

Human papilloma virus, which causes recurrent respiratory papillomatosis (RRP), was identified in 1980, and Kashima dedicated a significant portion of his career to caring for patients with airway manifestations of this infection. An astute clinical observer, Kashima noted cases of malignant transformation in patients with papillomatosis and hypothesized that the HPV virus could be a contributing factor in the development of head and neck malignancies. He was known for keeping meticulous records of papilloma growth rates and locations in his patients,¹⁷⁰ and he developed a scoring system for papillomatosis that is the basis for the Derkey system in widespread use today.¹⁷¹ Throughout his career, Kashima had a long and productive collaboration with Johns Hopkins pediatric oncologist Brigid Leventhal, with whom he conducted multiinstitutional studies on systemic treatment of papillomatosis.¹⁷² Their collaboration was a testament to the multidisciplinary care that Kashima provided for children with papillomatosis and made Johns Hopkins an international referral center for RRP.

Kashima was also a surgical innovator, known for his use of the CO₂ laser for papillomatosis and for refining the treatment of bilateral vocal cord paralysis. He popularized laser transverse cordotomy¹⁷³ and published extensively about the use of lasers in endolaryngeal surgery. A notable teacher and educator, Kashima trained a generation of Johns Hopkins otolaryngologists and was the recipient of many teaching awards throughout his long career. He was honored by the ALA with the Gabriel F. Tucker award in 1996 and the Newcomb award in 1997, and he was president of the ABEA in 1993.

The Modern Era of Laryngology/Bronchoesophagology

After Charles W. Cummings assumed the role of director, he recruited the next generation of laryngologists to join Haskins Kashima and Bernard Marsh. Having trained under Cummings at the University of Washington in Seattle, Paul Flint was recruited in 1991 specifically to expand the laryngology program with emphasis on the basic science research program. During this period, the first studies utilizing gene transfer for laryngeal reinnervation were completed and subsequently funded by the NIH.^{174–183} Together, Cummings and Flint initiated the first U.S. FDA clinical trials investigating laryngeal

implants designed for the treatment of unilateral vocal fold paralysis.^{184–188} Other significant contributions included introduction of the laryngeal and tracheal microdebrider for use in airway stenosis and establishment of the Difficult Airway Response Team (DART).^{189–192}

The evolution of indwelling stents brought new challenges in airway management, necessitating a collaborative approach between OHNS, Anesthesiology, Pulmonary Medicine, and Thoracic Surgery. In the early 2000s, Rex Yung (pulmonary medicine); Steven Yang (thoracic surgery); and later, David Feller-Kopman (pulmonary medicine) played critical roles in creating a multidisciplinary team to manage critical airway stenosis. In the 1990s, anesthesiologists Lynnette Mark and Charles Beattie recognized the synergy between anesthesiology and OHNS; as a result, the first international multidisciplinary airway course at Johns Hopkins was held in September 1993. This course ultimately merged with the Society for Airway Management (SAM) Annual Meeting first held in 1996. Founding board members for SAM included Lynnette Mark and Paul Flint.

During this same period, the complexity of difficult airways grew with advancing technology, and there was a general understanding that airway management required standardization to minimize the risk of harm to patients. Standardization of airway management was now a necessity to minimize complications and the DART evolved. Based on data demonstrating successful reduction in frequency of emergent tracheostomy after implementation of the DART within the operating room, a system-wide approach was initiated to include the Emergency Department, intensive care units, and other areas with a high incidence of airway events. The DART program consisted of three initiatives, including operational, safety, and educational components. The program included representation from Anesthesiology, OHNS, General Surgery, Respiratory Therapy, and the Johns Hopkins medical–legal team. The primary goals were to coordinate resources and patient management; develop safety programs based on quality assurance reporting and prospective systems analysis to mitigate hazards; and standardize and sustain comprehensive training of faculty, residents, and staff.^{189–192} The DART program has become a model of its kind and has been implemented in various forms throughout the country.

Head and Neck Surgery

The story of head and neck surgery at Johns Hopkins is intertwined with national trends and events. In the early years, major cancer operations were the purview of general surgeons, whereas otolaryngologic surgeons were developing expertise in diagnostic endoscopy of the larynx, tracheobronchial tree, and esophagus, as well as in communication disorders. The latter development brought links with speech and language pathologists who were concerned with speech and swallowing ramifications of oral cancer. Thus, before the 1980s, the account of major head-and-neck cancer ablative surgery at Johns Hopkins is found in the biographies of surgeons such as Grant Ward, an associate professor of surgery who is credited with having done the first jaw–neck composite resection in 1932.¹⁹³ Ward later wrote a highly regarded textbook on head and neck surgery.

Haskins Kashima, recruited by George T. Nager in 1970 to lead the department's initiative in head and neck cancer, was a consummate gentleman who had trained under Joseph Ogura at Washington University in St. Louis, Missouri, and shared his mentor's inventive spirit. Kashima's research interests in laryngeal papillomatosis resulted in a seminal partnership in the 1980s with Keerti Shah of the Johns Hopkins University School of Hygiene and Public Health, who was an early investigator of the human papillomavirus.^{194,195} This was decades before the role of HPV in head-and-neck squamous cell carcinoma was even considered. That relationship set the stage for Johns Hopkins Otolaryngology's preeminence in unfolding the HPV role in head and neck cancer. At head and neck tumor conferences, Kashima often demonstrated out-of-the-box thinking not always embraced by other head and neck surgeons, which prefigured later attempts by others to use cryosurgery, ultrasound, subtotal laser resection, and other means to control the deadly and sometimes languishing disease.

At many other institutions, the transition from general surgery to otolaryngology dominance in head and neck surgery was gradual and not without contention. In the late 1970s and early 1980s, Johns Hopkins otolaryngology residents remember performing complex head and neck surgery cases with Kashima at The Johns Hopkins Hospital and with Robert Chambers at GBMC. Chambers was a general surgeon and the senior partner in an active head-and-neck surgery private practice group in Baltimore. Chambers took a partner, Darrel Jacques, and both trained general surgery and otolaryngology residents. Jacques later added Richard Hirata and John Saunders to the group. Jacques, Hirata, and Saunders routinely brought head and neck cancer cases to The Johns Hopkins Hospital and worked there with general surgery residents on Thursdays while working with otolaryngology residents at GBMC on other days.

Two professional societies formed for academic interactions among head and neck surgeons: the Society of Head and Neck Surgeons (SHNS), founded by Hayes Martin and general surgery colleagues in 1954 (<http://www.ahns.info/about-ahns/history/>), and the American Society for Head and Neck Surgery (ASHNS), founded by John Conley and otolaryngology colleagues in 1958 (<http://www.ahns.info/about-ahns/history/>). Ward, Chambers, Jacques, and Saunders all served as presidents of the SHNS, whereas Michael M.E. Johns and Charles W. Cummings were ASHNS presidents. In fact, the mutual respect, friendship, and cooperation of Saunders and Cummings helped pave the way for the eventual merging of the two societies into the American Head and Neck Society in 1998 (<http://www.ahns.info/about-ahns/history/>), for which Wayne M. Koch and David W. Eisele have served as president. Of note, several Johns Hopkins-trained OHNS have also served as ASHNS presidents: John A. Kirchner, Loring Pratt, and Hugh Biller. That translates to 11 of the 90 past presidents of the major U.S. head and neck surgery societies with a Baltimore–Johns Hopkins connection.

When Michael M.E. Johns assumed directorship of the Department of Otolaryngology in 1984, he brought with him fresh vigor for the emerging leadership and preeminence of otolaryngologists in head and neck surgical oncology. His steady insistence that the profession be called otolaryngology–head and neck surgery (OHNS) and not ENT elevated the mindset of all in the department to achieve prominence through excellence.

Johns recruited William J. Richtsmeier (who had trained at the University of Virginia with Robert Cantrell and Johns) from the University of Washington, Seattle, in 1985. Richtsmeier was joined in 1985 by John Price, who had trained at Walter Reed in Washington, DC, and had completed a fellowship with John Conley in New York. These head and neck surgeons promptly established a Johns Hopkins head and neck surgery fellowship, with Glenn Peters as the first trainee. Upon completing his fellowship, Peters returned to lead head and neck surgery at the University of Alabama, Birmingham. Subsequently, David W. Eisele was recruited out of residency training at the University of Washington to join the Head and Neck Surgery Division in 1988.

Johns' commitment to research was manifest in the equally fruitful mind of Richtsmeier, a pioneer surgeon scientist who was not satisfied with halfway understanding of why cancers do as they do. His research focused on both the immune response to cancer, particularly around the role of gamma interferon^{196,197} and the molecular biology of cancer, the need for human cancer cell lines in order to study cancer, and the promise of mouse xenografts for cancer research. When Wayne Koch began looking for surgeon scientist mentors with whom to study in head and neck fellowship training, he could identify only three in all of otolaryngology: one was Richtsmeier. It was the mutual commitment of Richtsmeier and Johns to the enterprise of training surgeon scientists that brought Koch to Johns Hopkins as the second head and neck fellow in 1987. Later head and neck fellows included Richard Scher (Duke), David Goldenberg (Penn State Hershey), Michael Spafford (University of New Mexico), and Robert Ferris (Pittsburgh), among others. The fellowship received recognition by the Joint Training Council of the ASHNS and SHNS in 1992.

Johns and Richtsmeier knew that busy surgeons could not supply all the firepower needed for a first-rate research enterprise. They approached Johns Hopkins molecular oncologist Bert Vogelstein in search of a physician scientist to join the department and lead the head-and-neck cancer research laboratory. After a failed first attempt, it was left to Charles W. Cummings to seal the deal in recruiting David Sidransky from Vogelstein's laboratory group in 1992 to that position. Thus began one of the most fruitful collaborative laboratory interactions in all of OHNS.

The Sidransky lab, partnering with clinician scientists Koch and later Joseph A. Califano III, has published hundreds of peer-reviewed articles, including many seminal works, and has given scores of trainees from both the United States and abroad their start in translational research. Among these are James Rocco (1995, Johns Hopkins residency), Robert Ferris (1996, Johns Hopkins residency), Cherie-Ann Nathan (1995, Johns Hopkins fellowship), and Jay Boyle (1992, Johns Hopkins residency), who are now leaders in their own right. Other prominent head and neck researchers with a Johns Hopkins connection include Marion Couch, Duane Sewell, Patrick Ha, Carole Fakhry, Sara Pai, and Nishant Agrawal. Clinical-translational and basic scientists trained in head and neck translational research have returned to home institutions in Italy, Turkey, China, Japan, Korea, Brazil, and other countries around the globe.

The Johns Hopkins Head and Neck Research Laboratory has established the role of the p53 oncogene in head and neck cancer^{198–200}; discovered the importance of numerous other

molecular markers and active agents, most particularly epigenetic regions of hypermethylation that effect gene function^{201,202} and launched the multi-disciplinary study of HPV in head and neck cancer—together with Keerti Shah and his mentee, Maura Gillison, in oncology.^{203,204}

Sidransky has long been a leader in identifying clinical benefits from molecular discovery, spawning the work of Califano to demonstrate the molecular underpinning of field cancerization and tumor progression²⁰⁵ and the use of molecular markers to identify cancer remnants at tumor margins.²⁰⁶ Together, this research enterprise successfully competed for the first SPORE grant cycle for head and neck cancer research funded by the National Institute of Dental and Craniofacial Research. The SPORE grant is now in its third 5-year cycle. Recent collaboration between the Sidransky and Vogelstein laboratories, led by Nishant Agrawal, resulted in Johns Hopkins' contribution to the whole-genome sequencing of head and neck cancer, published together with researchers from the University of Texas MD Anderson Cancer Center in the journal *Science*. This project has shown the importance of the Notch oncogene in head and neck tumors.²⁰⁷

Clinically, the Head and Neck Cancer Center at Johns Hopkins has also been a leader for many decades. Under Michael M.E. Johns' direction, the scope of head and neck surgery was allowed to expand and encompass new procedures spumed by some other clinical department leaders. Reconstruction using free tissue transfer was embraced as within the scope of OHNS, with Vice-Director Douglas Mattox as the first practitioner. Mattox was facile with scapular free flaps, which were the exclusive flaps done until he became chair of otolaryngology at the University of Maryland. Steven Shimotakahara, Mark Brown, and Marion Couch took on free-tissue head and neck reconstruction next, adding fibular, radial forearm, and other flaps to the armamentarium. Today, a reconstruction team of Patrick Byrne, Kofi Boahene, and Jeremy Richmon has made head and neck reconstruction both routine and highly innovative.

Johns also championed the head and neck service involvement in craniofacial resections at Johns Hopkins, encouraging Richtsmeier, Eisele, and Koch to work with Benjamin Carson in the Department of Neurosurgery on these challenging cases.²⁰⁸ Initially, John Price and Richtsmeier led the way teaching major head and neck resections and performing alloplastic bar reconstructions, total laryngopharyngectomies with gastric pull-up, and maxillectomy using the midfacial degloving approach.²⁰⁹ In addition, Eisele developed a strong referral relationship with the Division of Endocrinology and developed a busy head and neck endocrine practice.

Eisele had an early interest in laryngeal nerve monitoring during thyroid surgery. In the early 1990s, otolaryngology residents Raymond Schettino and Andrew Goldstone took interest in this methodology and developed the surface electromyographic endotracheal tube in an animal model. Eisele then performed the pre-FDA approval clinical trial for this monitoring system, which is widely used worldwide today during thyroid and parathyroid surgery.²¹⁰ Subsequently, Ralph P. Tufano became the department's first focused head and neck endocrine surgeon and first chief of the Division of Head and Neck Endocrine Surgery.

Eisele was also clinically active in sleep surgery and collaborated with Alan Schwartz and Philip Smith of pulmonary medicine in investigating electrical stimulation of the upper airway for the treatment of obstructive sleep apnea (OSA). In animal and clinical studies, they demonstrated the feasibility and therapeutic potential for hypoglossal nerve stimulation in OSA, a treatment option recently approved by the FDA.

When Charles W. Cummings became director, the Johns Hopkins Department of OHNS cemented its position as a national leader in head and neck surgical oncology. Cummings brought his own surgical expertise together with national and international prominence as editor in chief of the multivolume textbook that bears his name²⁶⁷ and as a leader in national organizations. He stimulated the team to excellence, challenging all to consider what was best for the patient, personally, medically, and ethically. He also recruited Joseph A. Califano III, Patrick Ha, Young J. Kim, and Ralph P. Tufano, doubling the size of the Division of Head and Neck Surgery.

Head and neck cancer care has long been multidisciplinary, and Johns Hopkins' approach has reflected that. David W. Eisele established the first formal Head and Neck Cancer Center at Johns Hopkins in the early 1990s, bringing together expertise in head and neck surgery with radiation oncology and medical oncology as well as surgical pathology, neuroradiology, dentistry, and speech–language pathology. Pathologist William Westra took an interest in head and neck surgical pathology and became an internationally recognized leader in the understanding of the progression of epithelial neoplasia, as well as the histopathologic manifestations of HPV-related cancer. Together with pathologist Justin Turner, Westra continues to provide innovative translational research and authoritative surgical pathologic diagnostics for the Head and Neck Cancer Center.

In 1988, Arlene Forastiere was recruited from University of Michigan Medical School and the Ann Arbor Veterans Administration Medical Center to join medical oncology at Johns Hopkins. Forastiere was already a leader in the Eastern Cooperative Oncology Group Institutional Grant, where she served as chair of the Head and Neck Section in the late 1980s and early 1990s. Among her accomplishments were leading the cooperative group in clinical trials refining the organ preservation approach of combined chemoradiation for advanced cancers of the larynx²¹¹ and pharynx. Her leadership position has now been assumed by Christine Chung, an expert in developing targeted drug approaches to head and neck cancer, and Hyunseok Kang. The addition of Harry Quon and Anna Kiess increased the number of multidisciplinary specialty leaders in radiation oncology.

This combined research and clinical strength placed the Johns Hopkins Head and Neck Cancer Center in the right place at the right time to unravel the mysteries of HPV-related oropharyngeal cancer. Maura Gillison, working with the Head and Neck Cancer Research Laboratory and Keerti Shah, wrote an article in 2007 confirming growing suspicion that HPV cancers were primarily found in the lingual and palatine tonsil. Gillison's careful demographic questionnaires elucidated for the first time that the risk of HPV cancer was related to orogenital sexual contact.²⁰³ Later, under her mentorship, Carole Fakhry was able to clearly delineate the improved prognostic picture for patients with HPV cancer compared to smoker–drinker cancer patients.²⁰⁴

In recent years, the Head and Neck Division has attained a leadership role in transoral robotic surgery under the direction of Jeremy Richmon.²¹² This innovative approach dovetails nicely with the Head and Neck Cancer Center's prominence in HPV-related disease management. Christine Gourin came to Johns Hopkins in 2007 to lead the Head and Neck Division in outcomes and cost-effectiveness studies,²¹³ adding yet another dimension to the research and clinical capabilities of the group.

Pediatric Otolaryngology

The foundations of pediatric practice in otolaryngology and audiology have been covered in previous sections, highlighting the contributions by John E. Bordley, William G. and Miriam Pauls Hardy, Harriet Haskins, and Hiroshi Shimizu. Michael M.E. Johns appointed Robert M. Naclerio as the first director of a pediatric otolaryngology division at Johns Hopkins in 1983. Naclerio participated in a 2-year NIH-sponsored fellowship under the direction of Lawrence Lichtenstein and Philip Norman prior to completing his residency at Baylor College of Medicine, Houston, Texas, and fellowship at Johns Hopkins. He joined the Johns Hopkins faculty in 1983. Naclerio established a fellowship training program in pediatric OHNS, with the first fellow completing training in 1988. Although only a handful of such fellowship programs functioned at that time, pediatric otolaryngology as a subspecialty has matured in the United States over the past 25 years, with over 30 active fellowship programs at present. Since its inception, the department has trained over 25 fellows who practice pediatric otolaryngology throughout the United States, most in academic centers and tertiary pediatric hospitals. Naclerio consolidated the clinical efforts for pediatric care within the Johns Hopkins Children's Center, with the clinical fellow functioning as the coordinator of inpatient consultation services. Residency training in pediatric otolaryngology at this time included both mentored clinics and independent hearing conservation clinics in outlying rural counties in Maryland. Resident training included continuity clinics at these remote sites, as well as referral for advanced diagnostics and surgical treatment at the Children's Center.

Naclerio also introduced advanced endoscopic sinus surgery for the treatment of refractory chronic sinusitis or complications of acute sinusitis in children.²¹⁴ These methods were adapted from adult endoscopic sinus approaches introduced in the United States by David Kennedy at Johns Hopkins in the 1980s. In addition, the microbiology of chronic sinusitis in children was established as a result of research efforts in the division that involved the prospective evaluation of surgical patients.²¹⁵

Bernard Marsh and Haskins Kashima practiced pediatric laryngology and bronchoesophagology at Johns Hopkins during this period. Marsh introduced fiberoptic airway endoscopy to the diagnostic paradigm for children with airway disease and was a master teacher and surgeon for techniques of retrieval of aspirated foreign bodies. He advocated the concept of animal laboratory training to simulate the technical challenges of removing foreign bodies from the airways of infants and young children.²¹⁶ He brought innovative techniques of airway reconstruction to Johns Hopkins, first used in the United States at the University of Cincinnati, Ohio, to rebuild the stenotic airways of children who required tracheotomy as a consequence of long-term intubation in the neonatal intensive

care unit. He used sutureless techniques with meticulously designed rib cartilage grafts to allow shorter periods of stenting.

Kashima was a pioneer in establishing the cause and epidemiologic features of RRP.²¹⁷ Children with RRP suffered both airway and voice disturbance and required multiple surgical procedures to maintain airway patency and understandable voice. Kashima's expertise and the resources of the Children's Center created an international referral center for affected children. He and Brigid Leventhal in oncology coordinated the first multicenter randomized trial of an adjuvant for this disease, administering interferon to slow the progression of RRP.¹⁹⁵

David Tunkel joined the Pediatric Otolaryngology Division in 1991 as the first fellowship-trained pediatric otolaryngologist at Johns Hopkins and became the division director in 1994. Building on the pediatric endoscopic sinus surgery expertise that already existed, he adapted minimally invasive techniques to treat the extensive chronic inflammatory and polypoid sinus disease seen in children with cystic fibrosis. The characteristics of cystic fibrosis-related sinusitis were studied clinically and radiographically.²¹⁸ The establishment and description of best surgical practices continues to be a primary mission of the division through careful review of its treatment outcomes. Resulting contributions to the field of pediatric otolaryngology include the surgical management of head and neck masses caused by nontuberculous mycobacterial infection²¹⁹ and a simple method to perform supraglottoplasty to treat young infants with laryngomalacia without the need for expensive or risky airway lasers.²²⁰

The resources of the pediatric sleep laboratory and the expertise of the Pediatric Pulmonary Division in the Johns Hopkins Children's Center allowed a more thorough understanding of children with complex airway disease and/or obstructive sleep apnea. David Tunkel and colleagues were among the first to introduce the concept of using polysomnography as a tool to assess children before decannulation from tracheotomy in the 1990s.²²¹ The earliest reported use of polysomnography to assess risk of respiratory compromise after adenotonsillectomy for children with sleep-disordered breathing came from similar collaborations in the Children's Center in 1992.²²² Additionally, this multidisciplinary approach has documented the efficacy of subtotal tonsillectomy combined with adenoidectomy in children with moderate obstructive sleep apnea.²²³ Team-oriented advanced airway management in the Children's Center has included pediatric otolaryngology at each step.

The Pediatric Otolaryngology Division expanded in the 1990s with the addition of Fuad Baroody, who completed the pediatric otolaryngology fellowship at Johns Hopkins and practiced pediatric otolaryngology with an emphasis on sinonasal disease and mechanisms of allergic response. Mark Richardson joined the department as an accomplished pediatric otolaryngologist and served as vice chairman under Charles W. Cummings. During the 2000s, David Brown joined the department and developed collaborative efforts with pediatric genetics colleagues in the diagnosis of hearing loss in young children. Stacey Ishman completed fellowship training at Hopkins, and also became one of the first pediatric otolaryngologists to become board certified in sleep medicine. She studied unique methods

of diagnosis and treatment of complicated children with refractory obstructive sleep disorders.²²⁴

Most recent additions to the Pediatric Otolaryngology Division are Emily Boss and Margaret Skinner. Emily Boss has studied health care disparities for common diseases such as otitis media and common procedures such as tonsillectomy, and she is a national leader in the domain of patient and family centered care and decision making.²²⁵ Margaret Skinner has established a multidisciplinary clinic for management of children with complex aerodigestive disorders, and she is a member of an international group to standardize tracheotomy care in children.²²⁶

Facial Plastic and Reconstructive Surgery

In the 1930s, Samuel J. Crowe visited Felix Nager's program in Switzerland. At that time he met a young surgeon, Walter Loch, and invited him to visit Johns Hopkins. Loch arrived at Johns Hopkins in 1933 and with a part-time faculty appointment established a clinical practice using The Johns Hopkins Hospital for surgical cases. He worked with Grant Ward, a head and neck surgeon on the faculty, and learned much about head and neck malignancies, especially temporal bone and glomus tumors. Starting in the 1940s, Loch became fascinated with nasal surgery, particularly rhinoplasty, and developed a busy nasal surgery practice in Baltimore. He spent many hours teaching residents from Johns Hopkins and elsewhere the fine points of both functional and cosmetic rhinoplasty. Cadaver courses and the use of homemade models were a big part of his teaching efforts. He was closely affiliated with the Maurice Cottle traveling course on nasal surgery and helped organize a 1954 rhinologic medicine course at Johns Hopkins. It was during that symposium and cadaver course that the idea of forming the American Rhinological Society (ARS) was generated. Loch served on its original board of directors. That society continues to flourish today, focusing on nasal physiology, disease, structure, and function (Eugene Kern, oral personal communication, 2014).

Many local otolaryngologists received training in rhinoplasty at the Cottle courses and at other venues around the country. A renewed interest in facial reconstructive and cosmetic surgery was growing among otolaryngologists. Several private-practice surgeons began teaching Johns Hopkins residents about facial plastic surgery, which included exposure to rhinoplasty, cosmetic facial surgery, and the treatment of trauma. Among them were N. Edward Nachlas, Albert Steiner, Alvin Wenger, and Bernard Kleiman from the 1960s through the 1980s.

The increased activities in facial plastic surgery created friction with the Plastic Surgery Division at Johns Hopkins. When George T. Nager became director in 1969, he was under pressure by the Residency Review Committee to provide facial trauma experience to the residency program trainees. He approached the School of Medicine's Dean Russell Morgan, requesting that half of the facial trauma be directed to the otolaryngology program and half to plastic surgery. Milton Edgerton, chief of plastic surgery, met this request with vociferous opposition; but when the dust had settled, Nager had his facial trauma referrals.

After Michael M.E. Johns became director in 1984, the first formal subspecialty divisions were formed within the department. One of these new divisions was Facial Plastic and Reconstructive Surgery. The first division director was Ira Papel, a graduate of the residency program under Nager's directorship and a member of the part-time faculty.

Facial plastic surgery gained a higher profile in the department. Residents now were routinely exposed to procedures such as facial reconstruction, maxillofacial trauma, head and neck cancer reconstruction, rhinoplasty, and facial cosmetic surgery. Clinics were established at both Sinai Hospital, and the Greater Baltimore Medical Center (GBMC) in Baltimore and Towson, respectively, and GBMC, which helped grow the practice and expose residents to more procedures.

Other faculty also assisted in head and neck reconstruction. John Price was very involved in rehabilitation of head and neck cancer surgery utilizing regional and local vascularized flaps. In 1989, the department's first microvascular free flaps for facial reconstruction were performed by Douglas Mattox and Ira Papel.

John Frodel was recruited from the University of Iowa in 1992, bringing with him special expertise in maxillofacial trauma. With the increasing clinical load, a fellowship in facial plastic surgery was organized in 1993 in cooperation with the American Academy of Facial Plastic and Reconstructive Surgery. The first fellow was Theda Kontis, following her residency training at Johns Hopkins. As of 2013, the division has trained 16 fellows, many who work in academic centers in the United States and abroad.

In 1998, following the departure of John Frodel, who had been recruited to the University of New Mexico, Albuquerque. G. Richard Holt was recruited to be chief of the division. Holt had been the founding chair of otolaryngology at the University of Texas, San Antonio. This was a tremendous recruit as he was an established national leader in both otolaryngology and facial plastic surgery. He brought significant expertise to the department in maxillofacial trauma and reconstruction and also was an outstanding role model for professionalism to the trainees and junior faculty. Holt's tenure was impactful but short; he assumed the position of executive vice president of the American Academy of Otolaryngology–Head and Neck Surgery in 2000.

In 2001, Patrick Byrne joined the department as division director following his residency training at UC San Diego and fellowship at the University of Minnesota. Subsequent additions have included Kofi Boahene from the Mayo Clinic in Rochester, Minnesota, and the University of Minnesota and Lisa Ishii from Johns Hopkins residency and plastics fellowship. With three full-time faculty members, the division has markedly expanded the clinical, research, and educational enterprise. The division is unique among its peers at other academic medical centers for this broad contribution. All clinical areas of facial plastic and reconstructive surgery are practiced within the division. In addition to the full-time faculty, residents and fellows work on a regular basis with part-time faculty in the division. In addition to Ira Papel, Theda Kontis (Johns Hopkins residency, 1988) and Randy Capone (Johns Hopkins residency, 1998) spend significant time in facial plastic surgery education. Fellowship training in facial plastics and reconstructive surgery (FPRS) at Johns Hopkins

was further legitimized and standardized with its accreditation by the Johns Hopkins Graduate Medical Education Committee in 2004 and by the American Academy of FPRS in 2005. The resulting success at Hopkins has contributed to the evolution of the subspecialty in the United States as more programs seek to reproduce a similar model of resident and fellow training.

Several important contributions to the field over the last decade from the facial plastic surgery faculty include the popularization of temporalis tendon transfer for facial paralysis reconstruction²²⁷; the development of modern rhinoplasty techniques^{228–230}; the description and implementation of novel, three-dimensional surgical guides for complex nasal reconstruction²³¹; and development of advanced facial volume restoration techniques.^{232–234} The decision making and technical repertoire used in facial nerve reanimation have also been advanced through the use of new prediction models of prognosis that allow for earlier reconstructive interventions,²³⁵ as well as novel approaches to facial reanimation such as use of the masseter nerve.²³⁶ The introduction of objective assessment of facial deformities using quantitative eye-gaze tracking tools and qualitative instruments by Ishii has opened a new era of research in facial reconstruction and aesthetic surgery focused on outcomes and validation of best practices.^{237–242} Furthermore, in collaboration with Alberto Quinones-Hinojosa from the Department of Neurosurgery, Boahene has described new surgical corridors to the skull base, including the subfrontal approach²⁴³ and paramandibular endoscopic access.²⁴⁴ Byrne serves as a coprincipal investigator on the Johns Hopkins Face Transplant team initiated between the departments of OHNS and plastic and reconstructive surgery.²⁴⁵

Rhinology

According to legend, rhinology had a somewhat ignominious start at Johns Hopkins. In the early years, residents used to sleep in rooms around the upper floors of the dome of the hospital. Apparently, one resident lacerated the carotid artery while performing a sphenoidotomy and the patient died. That night, the resident committed suicide by leaping off the balcony and landing at the feet of the large white marble statue of Jesus Christ, which still resides in the original hospital entrance.

Despite this purported tragedy, Johns Hopkins, even at that time, was demonstrating significant leadership within the field of rhinologic innovation. In 1910, the same year that Oskar Hirsch described his multistage intranasal approach, an otolaryngologist at Johns Hopkins, Montgomery West, also described a multistage intranasal approach to the pituitary.²⁴⁶ Harvey Cushing collaborated with Samuel J. Crowe and John Romans, performing more than 100 canine pituitary procedures. Cushing went on to perform 74 pituitary procedures on patients at Johns Hopkins, primarily through the transsphenoidal route. He published his landmark text, *The Pituitary Body and Its Disorders*, in 1912,²⁴⁷ shortly before leaving Johns Hopkins.

As division director, Crowe visited St. Galen in Switzerland, and in the 1930s recruited Walter Loch to Johns Hopkins. A meticulous otologist and rhinologist totally devoted to his profession and to teaching, Loch became a close friend of Maurice Cottle and along with

other rhinologists began to teach courses on rhinology nationally. The ARS was “born on a hot humid night in Baltimore, delivered by a group of dedicated and very tired rhinologists who met in a small hotel room after some 14 hours of intensive teaching in one of the early ‘Cottle’ courses,” which was being given in 1954 at Johns Hopkins.²⁴⁸ In his guest of honor address on the 25th anniversary of the founding of the ARS,²⁴⁸ John E. Bordley predicted the rise of rhinology as a subspecialty within otolaryngology, stating that residents ultimately may need formalized subspecialty training in the area following their residency training, even alluding to the concept of subspecialty certification. In fact, the first-ever fellowship in rhinology was subsequently developed at Johns Hopkins in 1988.

Donald F. Proctor (Fig. 30), an otolaryngologist who had the distinction of being the first head of anesthesiology at Johns Hopkins while holding a joint appointment in environmental medicine in the School of Public Health, is internationally recognized as one of the early pioneers in the study of nasal physiology and mucociliary clearance. His work spurred much of the science on mucociliary clearance and nasal physiology in Europe. Clinically, he was an early adopter of the Johns Hopkins telescope for endonasal diagnosis and as early as 1966 taught that “the ethmoid sinuses are usually the key to any problem involving infectious sinusitis. Infection generally begins there and persistent infection there is usually the reason for failure of therapy directed at any of the other paranasal sinuses.”²⁴⁹ In the mid-1970s, a lecture at Johns Hopkins by Hamilton S. Dixon—the pioneer of microscopic ethmoidectomy²⁶⁸—led to the broad introduction of the microscope for transnasal ethmoidectomy and for transnasal skull base surgery outside of the field of pituitary surgery at a time when other academic institutions were still using external or headlight approaches.

To a significant extent, the later development of rhinology at Johns Hopkins grew out of the institution's experience with skull base surgery. The lateral rhinotomy approach for intranasal and skull base tumors was first published in 1949²⁶⁹ by John E. Bordley and William Longmire, a protege of Alfred Blalock who later became the founding chairman of surgery at the UC Los Angeles. Bordley subsequently published a series of 40 cases.²⁵⁰

Upon completing his residency under George T. Nager, David W. Kennedy (Fig. 31) joined the faculty primarily as an otologist with an interest in the new field of skull base surgery in 1978. In 1984, Kennedy organized one of the first courses in the developing specialty of skull base surgery and acted as guest editor for a series of special journal editions devoted to this topic. In 1984, Kennedy met with Walter Messerklinger in Dubrovnik, Croatia. It was there that Kennedy first learned about the potential for substituting the endoscope for the microscope in performing intranasal ethmoidectomy.²⁵¹ This meeting, combined with Donald F. Proctor's background teaching in nasal physiology and mucociliary clearance, led to a series of rabbit experiments and to the publication of the first articles on the theoretical aspects of functional endoscopic techniques and endoscopic sinus surgery.^{252–254} The encouragement of Michael M.E. Johns led to the world's first course on endoscopic sinus surgery, which was held at Johns Hopkins in 1985 (Fig. 32). Although two courses were held each year, there was a long waiting list for participation in the course for several years. Because of the strong history of interdisciplinary cooperation at Johns Hopkins, the team rapidly extended endoscopic techniques to the management of skull base defects; orbital decompression; and, still in the 1980s, to early procedures with endoscopic pituitary surgery

and management of benign and malignant skull base lesions. The first International Symposium of Infection and Allergy of the Nose (ISIAN) in the United States was held at Johns Hopkins in 1989, in conjunction with the 100th anniversary of the opening of The Johns Hopkins Hospital. When Kennedy left Johns Hopkins in 1991 to become the chair at the University of Pennsylvania, Johns Hopkins did not formally have a division of rhinology. Nevertheless, Johns Hopkins was clearly established as the leading institution within the continually developing subspecialty of rhinology.

After Kennedy's departure, his legacy in endoscopic sinus surgery was sustained by Robert M. Naclerio, Mark Loury, and Donald Leopold. In the early 1990s, a clinical and research focus in rhinology was developed at the Johns Hopkins Bayview Medical Center campus in collaboration with colleagues at the Allergy and Asthma Center. This collaboration has continued under the leadership of Jean Kim (Johns Hopkins residency, 1996). Johns Hopkins continued its international reputation for excellence in rhinology and remained at the forefront of rapid advancements and refinements in endoscopic sinus surgery, including powered instrumentation, image-guided surgery, and minimally invasive techniques. The annual Johns Hopkins endoscopic sinus dissection course remained a well-attended and highly regarded event. In addition, continuing in Proctor's scientific tradition, Naclerio and Leopold were successful clinician researchers who advanced the field through their investigations of the physiology of nasal function, inflammatory disease, and olfaction.

In 2001, Charles W. Cummings recruited David Kennedy's fellow at the University of Pennsylvania, Philadelphia, Andrew Lane, to join the faculty and rekindle the rhinology torch at Johns Hopkins. In 2003, Lane was named chief of a formal Division of Rhinology and Sinus Surgery by the next director, Lloyd B. Minor. The division flourished in the ensuing decade, expanding to six members, three who have advanced fellowship training in rhinology. The division's expertise spans the breadth of rhinology, with recent growth in programs in endonasal skull base surgery, led by Douglas Reh and Masaru Ishii, and otolaryngic allergy, led by Sandra Lin. Research in the Rhinology Division has similarly blossomed, becoming the top program for federal grant funding and achieving national prominence as the leader in basic science rhinology research. Lane's academic leadership has advanced understanding of the genetic basis of innate sinonasal immunity and its role in chronic sinusitis,^{255,256} leading to the establishment of new experimental models.²⁵⁷ Other recent contributions include the popularization of sublingual immunotherapy by Sandra Lin and colleagues,²⁵⁸ and the introduction by Douglas Reh and colleagues of perioperative continuous cerebrospinal fluid monitoring in the management of spontaneous leaks.²⁵⁹ Jean Kim^{260–262} and Murugappan Ramanathan^{263,264} have contributed significantly to knowledge of the role of sinonasal epithelial cells in driving and perpetuating inflammation in chronic rhinosinusitis.

Future Directions

From the example of William S. Halsted, academic OHNS has grown in the United States from an intellectual endeavor that seeks knowledge and its applications to better patient care and outcomes. This Johns Hopkins tradition has been shaped by medical history, leadership style, technological capabilities of the time, and institutional culture. This account of the

past 100 years highlights the importance of collaboration and mentorship in the process of program building and innovation. Countless individuals have not been mentioned, however without them, the legacy of The Johns Hopkins Hospital and the Department of OHNS would not have been possible. It is a humbling responsibility to carry on this century-old tradition, but one that today's faculty is happy to embrace. Central to this mission is maintaining a culture of inquiry bolstered by collegiality and inclusiveness. The past exclusion of talent based on gender, race, ethnicity, and religion had untold consequences on the potential achievements of the institution and its contributions to the field. Our emphasis on maintaining a learning and work environment that values professionalism and the inclusion of women and minorities is now critical to the recruitment and retention of high-quality talent to the specialty. The growing understanding of principles of adult learning and the importance of professionalism to patient safety, employee satisfaction, and intellectual productivity of our trainees and faculty requires an expansion of our academic efforts to include these areas.

The next century of the Johns Hopkins Department of OHNS will build on the progress made in its first 100 years. The department's missions will have more international impact because overseas outreach in education will be a focus. Expansion of clinical care and training programs will occur, along with a larger, national clinical practice footprint. Training of future leaders in clinical care and research will expand. More important, new discoveries will be made and translated to clinical applications. This, along with clinical care innovations, will continue to be the hallmark of the Johns Hopkins Department of OHNS.

The Establishment of the Crowe Society With Its Mission Statement

Upon the urging of then director Charles W. Cummings, the Crowe Society was founded in June 1991 by alumni, along with past and present faculty, to fulfill its mission as laid out in the bylaws that follow. Inaugural officers of the society included Roy Schottenfeld, Marion Ridley, Ira Papel, and Loring Pratt.

The Crowe Society and Bylaws: Department of Otolaryngology–Head and Neck Surgery Alumni Association Constitution

ARTICLE I

NAME

The name of this society shall be the Crowe Society.

ARTICLE II

PURPOSES

The purpose of this Society shall be:

1. To assist residents in training in the Department of Otolaryngology–Head and Neck Surgery at The Johns Hopkins University and to achieve excellence by supporting their research and educational activities.

2. To advance the art and science of otolaryngology by promoting educational, scientific, and community functions.
3. To encourage fellowship among the alumni and faculty of the department.

ARTICLE III

OFFICERS

Section 1. The officers of the Society shall be:

The President

The President-Elect

The Secretary-Treasurer

Section 2. Officers shall be elected and shall serve a two-year term. The President-Elect, at the expiration of his/her term of office, shall automatically succeed to the office of President.

Section 3. The Executive Committee shall consist of the President, the President-Elect, the Secretary-Treasurer, two Council-at-Large, and the Chairman of the Department of Otolaryngology-Head and Neck Surgery at The Johns Hopkins University.

The Executive Committee shall have discretionary power to administer the affairs of the Society and to consider all matters to be presented to the Society at large.

ARTICLE IV

MEETINGS

Section 1. A meeting of the Society shall be held each year in conjunction with the Annual Meeting of the American Academy of Otolaryngology-Head and Neck Surgery or the Biennial Meeting of The Johns Hopkins Medical Surgical Association.

ARTICLE V

MEMBERSHIP

Section 1. Active Members. All graduates of the Department of Otolaryngology-Head and Neck Surgery of The Johns Hopkins University, all past and current faculty members, fellows, including those who hold adjunct and volunteer appointments in the Department shall be eligible for Active Membership in the Society. Graduating Residents will be awarded a one-year membership in the Society upon completion of their training. Continuation of membership shall be subject to compliance with Article VI.

Section 2. Associate Members. Graduates and members of paramedical programs within the Department shall be eligible for Associate Membership in the Society.

Section 3. Honorary Members. The Society may elect to offer Honorary Memberships to individuals, who would not otherwise be eligible, whose contributions to the Department have, in the opinion of the Society, merited their membership. Honorary Members may not vote, or hold office, or serve on committees in the Society.

Section 4. Senior Members. Active and Associate Members, at the age of sixty-five years, shall be designated Senior Members. Membership in this category shall not alter their privilege to vote, serve on special committees, or hold office.

ARTICLE VI

DUES AND FUNDS

Section 1. No annual dues will be assessed for membership in the Society; however, contributions to the Samuel Crowe Society will afford all eligible individuals admission into the Society. No contributions will be used for administration of the Society.

Section 2. Certificates. The Secretary-Treasurer shall send a Certificate of Membership in the Society to each member in good standing. This Certificate shall be signed by the officers of the Society.

Section 3. Management of Society Funds. Management of Society Funds will be at the discretion of the Executive Council.

Section 4. Distribution of Funds upon Dissolution. In the event of the dissolution of this Society, any residual funds in its treasury and all unpaid notes shall be paid over and delivered to The Johns Hopkins University for the use and benefit of the Department of Otolaryngology–Head and Neck Surgery.

ARTICLE VII

AMENDMENTS

This Constitution may be amended by a vote of two-thirds of the members present at any meeting, provided such amendment shall have been submitted to the Secretary-Treasurer in writing at least three (3) months prior to the date of such meeting and by the Executive Committee to the membership in writing at least one (1) month prior to the date of such meeting.

Bylaws

ARTICLE I

COMMITTEES

Such committees deemed necessary shall be appointed by the President to serve as long as the purpose requires.

ARTICLE II

DUTIES OF OFFICERS

President: The President shall preside at all regular meetings of the Society, unless prevented by illness or by some other unavoidable circumstances. The President shall appoint the Councilmen-at-Large and all interim and temporary committees for special purposes. The President shall be Chairman of the Executive Committee.

President-Elect: The President-Elect shall preside at regular meetings of the Society on the unavoidable absence of the President.

Secretary-Treasurer: The Secretary-Treasurer shall keep minutes of all regular meetings of the Society and all official meetings of the Executive Committee. He/she shall read the minutes of the previous Society meeting at each regular meeting and shall read an annual report of the proceedings and actions of the Executive Committee at each *regular meeting* of the Society. He/she shall keep strict account of all funds received by the Society and render a report to the Society at each regular meeting.

If the Secretary-Treasurer is unable to attend any given meeting, another active member of the Society may be designated to read the reports and to keep minutes.

The Secretary-Treasurer shall conduct such correspondence on behalf of the Society as may be necessary to its administration.

ARTICLE III

The Active and Associate Members present at the meeting shall constitute a quorum for business.

ARTICLE IV

All questions before the Society shall be determined by the majority vote of those present at any regular meeting.

ARTICLE V

The usual parliamentary rules governing deliberative bodies shall govern the sessions of the Society.

ARTICLE VI

These bylaws may be amended at any meeting of the Society by a majority vote, provided such amendments have been submitted to the Secretary-Treasurer at least one (1) month prior to the meeting and have been reviewed by the Executive Committee, which shall indicate to the meeting its approval or disapproval of the proposed amendment.

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Fig. 1.
The Johns Hopkins Hospital, 1889. Photographer unknown. Courtesy of The Alan Mason Chesney Medical Archives of The Johns Hopkins Medical Institutions. [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

Fig. 2.
William S. Halsted, by Thomas C. Corner, oil on canvas, 1936. Photograph by Aaron Levin.
Courtesy of The Alan Mason Chesney Medical Archives of The Johns Hopkins Medical
Institutions. [Color figure can be viewed in the online issue, which is available at
www.laryngoscope.com.]

Fig. 3. Samuel J. Crowe (1883–1955), by Jacques Maroger, oil on canvas, 1954. Photograph by Aaron Levin. Courtesy of The Alan Mason Chesney Medical Archives of The Johns Hopkins Medical Institutions. [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

Fig. 4. Johns Hopkins Hospital laryngology and otology staff, group portrait, circa 1931. Samuel J. Crowe seated in center. Photographer unknown. Courtesy of The Alan Mason Chesney Medical Archives of The Johns Hopkins Medical Institutions.

Fig. 5.

John E. Bordley (1902–1993), by William F. Draper, oil on canvas, 1968. Photograph by Aaron Levin. Courtesy of The Alan Mason Chesney Medical Archives of The Johns Hopkins Medical Institutions. [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

Fig. 6.
John E. Bordley (left) and Samuel J. Crowe in (right) conversation, circa 1950.
Photographer unknown. Courtesy of The Alan Mason Chesney Medical Archives of The
Johns Hopkins Medical Institutions.

Fig. 7. George T. Nager (1917–2010), by Wayne Ingram, oil on canvas, 1984. Photograph by Aaron Levin. Courtesy of The Alan Mason Chesney Medical Archives of The Johns Hopkins Medical Institutions. [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

Fig. 8. Stacy R. Guild (left) and George T. Nager (right) studying microscopic sections of temporal bones. Photographer and date unknown. Courtesy of The Alan Mason Chesney Medical Archives of The Johns Hopkins Medical Institutions.

Fig. 9. Michael M.E. Johns, by Herbert Abrams, oil on canvas, 1993. Photograph by Aaron Levin. Courtesy of The Alan Mason Chesney Medical Archives of The Johns Hopkins Medical Institutions. [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

Fig. 10.

From left to right: Samuel J. Crowe (by Jacques Maroger, oil on canvas, 1954), John E. Bordley, Michael M.E. Johns, and George T. Nager. Photograph by Leonard L. Greif. Courtesy of The Alan Mason Chesney Medical Archives of The Johns Hopkins Medical Institutions. [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

Fig. 11. Charles W. Cummings, by Peter Egeli, oil on canvas, 2001. Photograph by Norman Watkins. Courtesy of The Alan Mason Chesney Medical Archives of The Johns Hopkins Medical Institutions. [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

Fig. 12.

Lloyd B. Minor, by Peter Egeli, oil on canvas, 2011. Courtesy of The Alan Mason Chesney Medical Archives of The Johns Hopkins Medical Institutions. [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

Fig. 13.

David W. Eisele, 2013. Photograph by Keith Weller. [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

Fig. 14.

Current and former directors of the Johns Hopkins Department of Otolaryngology–Head and Neck Surgery. Portraits from left to right: George T. Nager, Samuel J. Crowe, John E. Bordley; in the foreground from left to right: Uoyd B. Minor, Charles W. Cummings, David W. Eisele, Michael M.E. Johns. Photograph by Keith Weller, 2014. [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

Fig. 15.
Stacy R. Guild seated portrait in laboratory, circa 1965. Photographer unknown. Courtesy of
The Alan Mason Chesney Medical Archives of The Johns Hopkins Medical Institutions.

Fig. 16.

From the Max A. Goldstein/CID Collection, courtesy of Central Institute for the Deaf (St. Louis, MO.) [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

Fig 5. *Top*, Cross section to show position of monel metal radium applicator in nasopharynx. *Bottom*, Photograph of child during treatment with applicator in position.
From: Proctor, D. F., Polvogt, L. M. and Crowe, S. J.: Irradiation of lymphoid tissue in diseases of the upper respiratory tract. *Bull. Johns Hopkins Hosp.*, 83: 383, 1948.

Fig. 17.

Figure from Donald F. Proctor consisting of cross section (top) showing position of monel metal radium applicator in the nasopharynx, and photograph (bottom) of child during treatment.²⁶⁵ Photographer and figure artist unknown. Courtesy of The Alan Mason Chesney Medical Archives of The Johns Hopkins Medical Institutions.

Fig. 18.

John E. Bordley and Stacy R. Guild. Date and photographer unknown. Courtesy of Robert J. Ruben. [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

Fig. 19.

John E. Bordley (left) and William G. Hardy with a patient. Original printed in Johns Hopkins Magazine, December 1950. Photographer unknown. Courtesy of The Alan Mason Chesney Medical Archives of The Johns Hopkins Medical Institutions.

Fig. 20. Miriam Dorothy Pauls with a patient. Original printed in Johns Hopkins Magazines, October 1950. Photographer unknown. Courtesy of The Alan Mason Chesney Medical Archives of The Johns Hopkins Medical Institutions.

Fig. 21.
Hiroshi Shimizu at work in Hearing and Speech Clinic Laboratory, The Johns Hopkins Hospital, 1979. Photographer unknown. Courtesy of The Alan Mason Chesney Medical Archives of The Johns Hopkins Medical Institutions.

Fig. 22.

Lloyd B. Minor, George T. Nager, and John P. Carey described the histopathologic features of Superior canal dehiscence syndrome in human temporal bones.⁸⁷ Published in Hopkins Medical News, “The Clue in the Old Bones” by Jim Duffy, vol. 22, no. 3 (Spring/Summer 1999). Photographer unknown. Courtesy of The Alan Mason Chesney Medical Archives of The Johns Hopkins Medical Institutions. [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

Fig. 23.
Edward M. Walzl, circa 1940. Photographer unknown. Courtesy of The Alan Mason Chesney Medical Archives of The Johns Hopkins Medical Institutions.

Fig. 24.
Team members of the Robert J. Ruben laboratory, circa 1962. Photograph features Diran Mikaelian, MD; Dickens Wardel Warfield PhD; and Mr. Robert Glacken. Courtesy of Robert J. Ruben.

Fig. 25.

Robert J. Ruben (left) and Bobby Alford (right) examining electrocochleography readings in the operating room, circa 1960. Photographer and year unknown. Photographer unknown. Courtesy of Robert J. Ruben.

Fig. 26.
Murray Sachs, 1994. Photographer unknown. Courtesy of The Alan Mason Chesney Medical Archives of The Johns Hopkins Medical Institutions.

Fig. 27.

Edwin N. Broyles by Isabella Hunner Parsons, oil on canvas, 1963. Photograph by Aaron Levin. Courtesy of The Alan Mason Chesney Medical Archives of The Johns Hopkins Medical Institutions. [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

Fig. 28.

Edwin N. Broyles performing laryngoscopy at The Johns Hopkins Hospital, circa 1958. Photographer unknown. Courtesy of The Alan Mason Chesney Medical Archives of The Johns Hopkins Medical Institutions. [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

Fig. 29.
Haskins "Chuck" Kashima. Year and photographer unknown.

Fig. 30.

Donald F. Proctor, oil on canvas by Ann Dldusch Schuler, 1983. Photograph by Aaron Levin. Courtesy of The Alan Mason Chesney Medical Archives of The Johns Hopkins Medical Institutions. [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

Fig. 31.
David W. Kennedy, 1988. Photographer unknown. Courtesy of The Alan Mason Chesney Medical Archives of The Johns Hopkins Medical Institutions.

Fig. 32.

Brochure for the first training course in endoscopic sinus surgery. Courtesy of Dr. David Kennedy.