Engineering Cha

By identifying needs in medical technology and innovating their solution, engineer turned anesthesiologist James H. Philip, MD '73, has made a lasting imprint on operating room safety.

2023 Award Winner

According to family lore, James H. Philip, MD '73, demonstrated his first prowess at engineering problem solving at less than two years old when he got hold of a screwdriver his father had left adjacent his crib, unscrewed the side panel, and made his escape.

That technical skill may have been partially genetic; Philip's father was a civil engineer whose last project was serving as principal concrete engineer on construction of the World Trade Center Twin Towers.

When his father brought home some telephones from a construction site after the completion of a job, Philip made them the subject of his first electrical engineering experiment. "They were push-button phones. You pushed any button to select one call at a time," he recalls.

Philip took those phones apart, following every wire to figure out how to reconnect them. He also figured out that there were triangular spacers that prevented the user from pushing more than one button at a time. Once he removed those spacers with forceps and a screwdriver, he could push all five buttons at once, effectively having five people on a call. "It was the first communications solution I ever made," Philip says. "My dad invited me to each new project to upgrade the phone so he could get all the subcontractors on a project on the same call."

Philip learned an important lesson he'd carry with him. "Hacking is very important," he says. "We look for problems and we build workarounds until we can solve the problems for good, with a real solution."

Beverly and James Philip on the construction site of the World Trade Center Twin Towers, where his father served as principal concrete engineer

For more than 50 years, Philip has used that inquisitive skill to engineer the medical environment—filling needs and developing devices that are safer, more effective, and less costly than what was standard before, improving the delivery of healthcare in measurable ways.

Now professor of anaesthesia at Harvard Medical School, Philip has received numerous honors for his contributions, most recently, being named the 2023 Distinguished Alumnus by the Upstate Medical Alumni Foundation.

"I was able to take what I'd learned from engineering and apply it to my medical career," says Philip, who says that is an example anyone can benefit from.

"I tell students all the time to take what they've learned and apply it to where they are going. Learn what you can in every aspect of your life: personal, educational, professional, and social," he says. "Apply the positives you learn and shed the negatives."

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Dr. Philip receives his Distinguished Alumnus cane. From left, Upstate President Mantosh Dewan, MD, Philip, Alumni Foundation President Larry Charlamb, MD '88, and Norton College of Medicine Dean Lawrence Chin, MD

With his success at creating conference call capability on a push-button telephone, Philip went to Cornell University to study electrical engineering. He was recruited to Hewlett Packard Medical through the Cornell Co-Op program. Each summer, he'd be given a project and develop a product.

After 5 p.m., interns were allowed to use the Hewlett Packard (HP) labs to design and build their own independent projects to help them learn. Philip built a disco light system that he would go on to rent to individuals and businesses for $35 a night. He called the device a Psylume and what it produced was psycholuminescence.

The Philips on one of their many travel adventures

While earning both bachelor's and master's degrees at Cornell, he worked co-op and summer jobs at HP Medical as a research and development engineer. In his first year, Philip helped develop the first brightness control that automatically adjusts the brightness of monitors in the operating room based on the brightness of the room, the defibrillator energy measure, and a multi-patient EKG recorder.

Over his seven-year experience with HP, Philip learned that many of the projects HP developed originated from marketing surveys sent to physicians. He also saw that many of those products ultimately did not sell well. "I had this realization that the products physicians wanted weren't really what they needed," he says. "That's when I decided that I would go to medical school to try to identify those needs, create the products, and really make an impact in health care."

On his first day of medical school at the SUNY Upstate Norton College of Medicine, Philip was standing in line in the cafeteria when he saw a pretty young woman wearing a Star of David necklace. That woman was classmate Beverly Khnie, MD '73, and they later ended up in a group studying for an anatomy exam in the library. The group decided to go out to dinner, but fortuitously, it ended up being only he and Beverly.

"I took her to a Chinese restaurant on Erie Boulevard that I knew had a band on Thursday nights," he says. "I discovered another thing we had in common—we were both really good dancers." Later, they began skiing together every weekend.

He and Beverly became part of a tight-knit group of eight students that referred to themselves as DISEASE, an acronym for Disturbed Iconoclastic Students Emphatically Against Serious Endeavor. "We spent a lot of time together in thoughtful discussion about all aspects of life," he says.

They married during their third year of medical

school, around the same time that he developed an interest in anesthesiology. At that time, the rate of bad outcomes—death or near death—from anesthesia was one in 3,000. "I felt it was the most dangerous specialty and needed the most engineering," he says. "It was very technical and electrical engineering-oriented and I understood monitoring and converting physiological phenomena in the body into electrical activity that one could look at on a monitor."

Beverly also chose to pursue anesthesiology for her own reasons and the couple interviewed for residency positions together, ultimately choosing Peter Bent Brigham Hospital because the residency director was amenable to scheduling the couple on call together, which would also provide time off together. "He understood the importance of interpersonal relationships," says Philip.

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After residency, Philip stayed on at Brigham while Beverly joined the faculty at the Boston Hospital for Women. Three years later, those hospitals merged, becoming Brigham and Women's Hospital. The Philips have remained anesthesiology colleagues and collaborators ever since.

"The practice of anesthesiology requires the continuous resuscitation during the ongoing administration of lethal drugs," says Philip. "Every drug I give is dangerous. The therapy I provide is life preserving, and I must protect the patient against adverse outcomes and monitor and control the right things."

Philip became a member of the Anesthesia Standard Committee at Harvard Medical School, charged with developing anesthesia practice standards for the institution. He was co-author of the Harvard Anesthesia Monitoring Standard of 1984, published in *JAMA*, standards that were subsequently adopted worldwide.

Philip began focusing his attention on inhaled anesthetic agents, the mainstay of anesthesia practice, but a challenge for many. In an effort to both educate and improve safety, Philip created Gas Man®, a computer simulation, textbook, and learning environment that teaches students, clinicians, and researchers the kinetics, clinical use, and economics of inhaled anesthetics. He has taught anesthesiologists worldwide using Gas Man for more than 20 years, continuing to refine the software to keep pace with technology and with increasing understanding of these drugs and their delivery.

As one of the first successful educational computer simulations used in medicine, Gas Man heralded the advent of simulation throughout medical education. In 2023 Gas Man is being converted to a web-based program to be available as an Open-Source program.

Gas Man simulations led to developments in clinical practice. Drs. Beverly and James Philip originated and studied the anesthetic technique called Volatile Induction and Maintenance of Anesthesia (VIMA). A practical application of anesthetic kinetics by which anesthesia can be administered with a single inhaled drug, the technique is now used worldwide. He also reintroduced and studied a classic anesthetic technique, closed-circuit anesthesia, to enhance understanding of anesthetic uptake and distribution. "This technique also offers great cost reductions, making high-quality anesthesia more available worldwide, and reducing environmental pollution," says Philip.

His second area of innovation lies in the understanding of intravenous fluid infusion dynamics. Philip developed the science of high-flow fluid infusion using a device he created that produces constant pressure to drive liquid infusion into veins. Equipment using this constant pressure infusion principle has become the standard of care for fluid resuscitation worldwide.

Another major advancement was the measurement technique called hydraulic resistance, which Philip invented, published, patented, and licensed. This technique assesses the quality of intravenous infusion

Beverly and James in front of a display case containing his inventions—the Signature Pump and InfusOR—at top right

The Philips began skiing together while in medical school and are longtime members of the National Ski Patrol at Bromley Mountain in Vermont.

by varying flow rate and measuring the resulting pressure change. Importantly, this technology detects when infusions infiltrate from veins into tissues, saving patients discomfort and harm. The culmination of that work is the IVAC-Alaris- Carefusion Signature Edition™ Infusion Pump. In another application, he collaborated with researchers in the Harvard Department of Orthopedic Surgery to investigate the causative mechanism of avascular necrosis of the hip, for which they were presented the Hip Society's Stinchfield Award.

In the field of circulatory system dynamics, Philip identified the need for an accurate continuous monitor of cardiac output in the operating room and ICU, resulting in the multi-frequency thermodilution cardiac output monitoring technique embodied in the Edwards Lifesciences Vigilance® Continuous Cardiac Output Monitor. This monitor is the gold standard for invasive and noninvasive measurement and monitoring of cardiac output for research and is used in clinical care worldwide.

In the area of monitoring and safety, Philip and colleagues developed the first commercially successful clinical CO^2 monitor, Life-Watch™ by Perkin Elmer. Life Watch added continuous carbon dioxide monitoring to the Perkin Elmer mass spectrometer that previously provided intermittent measurement of gases in some operating rooms. Today continuous carbon dioxide monitoring is considered one of the great safety breakthroughs, having reduced anesthesia mortality by 99 percent, making anesthesiology the safety benchmark by which other specialties are judged.

Philip has received international recognition for his educational leadership and innovation. Among his many honors, he was awarded the Society for Technology in Anesthesia Gravenstein Award for lifetime achievement creating clinical technologic products and safety in anesthesia in 2017 and the ASA-SEA Distinguished Educator in Anesthesiology Award in 2021. He has served as an invited visiting professor more than 250 times and is a founding member and past president of the Society for Technology in Anesthesia.

Philip retired from clinical practice in July 2018 and now focuses on research and mentorship at his own and other hospitals and universities. He also spends one day per week supporting technology efforts in the Mass General Brigham HealthCare System Department of Anesthesiology and the Department of Biomedical Engineering as senior consultant and anesthesiologist.

He continues to collaborate with Beverly, professor of anaesthesia at Harvard Medical School, founding director of the Day Surgery Unit at Brigham and Women's Hospital, and recipient of the 2018 Distinguished Alumna Award from the Upstate Medical Alumni Foundation.

"One of the benefits of being in the same specialty is that we are very often speaking at the same meetings and use those as jumping off points for the many activities we enjoy," says Philip.

The couple are members of the National Ski Patrol at Bromley Mountain in Vermont, certified inline skating instructors, and have scuba dived together since medical school. Other passions include dancing, adventure travel, ocean kayaking, and mountain trekking, including Kilimanjaro, Machu Picchu, Annapurna Base Camp, and Europe's Haute Route. They have two married sons, Noah, a psychiatrist at Brown University, and Benjamin, a neuroscientist at Washington University in St. Louis and science fiction writer as Benjamin Kinney.

Philip is proud that he accomplished exactly what he set out to do: find medical needs and create products to solve them, improving safety in the process. That's nowhere more apparent than in his own field of anesthesiology.

"Bad outcomes have reduced to one in every 300,000 patients. Ninety-nine percent of patients who died from anesthesia in the past no longer die," he says. "The products I created touch patients in every operating room and the concepts that I continue to teach have become familiar to every anesthesiologist. I look forward to continuing that process of identifying and solving problems and facilitating change."