CASE STUDY: SANGEETA BHATIA

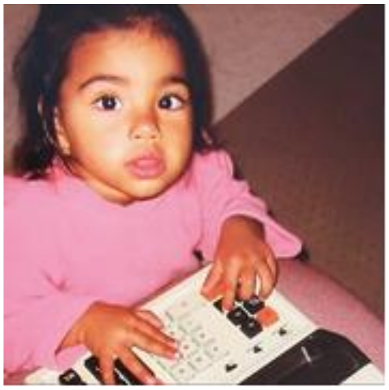
Introduction

Dr. Sangeeta Bhatia is an inventor, entrepreneur, and mentor who works in miniaturized technologies at the intersection of medicine and engineering, pushing scientific understanding out of the lab and into clinical applications. She has developed tools that can noninvasively diagnose and monitor disease using nanoparticles. Bhatia received the Lemelson-MIT Prize in 2014 for her groundbreaking inventions to improve human health in patient care on a global scale and dedication to the next generation of scientists.

Sangeeta Bhatia (Photo/Lemelson-MIT Program)

Early Years

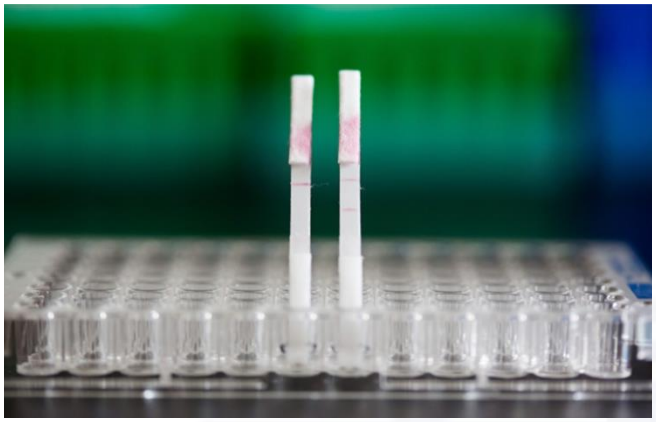
Sangeeta Bhatia grew up in Boston, Massachusetts, raised by parents who emigrated from India in the 1960s. Bhatia's parents pushed her and her sister toward excellence, and instilled in them a commitment to service. Bhatia always enjoyed and excelled in math and science, and benefited from teachers who believed in her. She attended a high-pressure school, where she learned to work hard to figure out problems, rather than giving up. This, combined with Bhatia's optimistic outlook on life, has helped her overcome challenges throughout her life. When experiments in the lab do not go the way she thought they would, she pushes out of her comfort zone and seeks the unexpected solution.



Bhatia as a baby. (Photo/Sangeeta Bhatia)

Bhatia's mother was one of the first women in India to receive a master's degree in business administration, but Bhatia lacked female role models in science. She did not fully understand what engineering was in high school, and did not meet a woman with a Ph.D. in science until she was 19 years old. Her father, an engineer, became her first mentor, seeing more for her than what she saw for herself. He noticed that Bhatia loved her high school biology class and pointed her toward the emerging field of biomedical engineering. He took Bhatia to visit a friend's bioengineering lab at the Massachusetts Institute of Technology, which captured her imagination and sparked an interest in how machines, math, and engineering could be used to improve human health.

Bhatia has always been motivated by human disease and drawn to global health, in part because of her early experiences. As a child, Bhatia went with her aunt, a physician, to a local clinic during summer visits to India. There, she observed medical care in a low-resource community, an experience that has resonated with her throughout her life. She witnessed firsthand the differences in cancer detection and care in low and middle-income countries — which lack screening infrastructure or readily available medicines — and the resource-rich United States. It occurred to her early on that a paper screening test that didn't require electricity or an on-site doctor could have a transformative impact on health outcomes in countries like India.



Test strips that are based on the same technology used in pregnancy tests and turn red when cancer is present. (Photo/MIT/Bryce Vickmark)

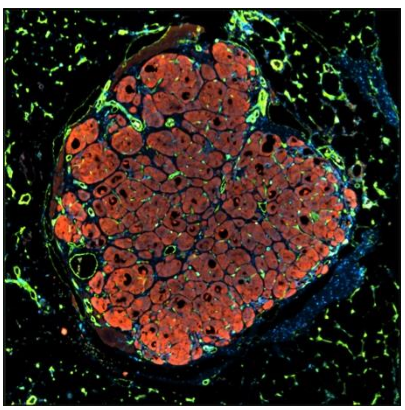
Bhatia attended Brown University in the mid-1980s, part of a freshman engineering class that included as many women as it did men. By the time Bhatia graduated, only 16 percent of all engineering students were women, starkly highlighting the gender disparity in the field. Bhatia held summer internships at biotech and pharmaceutical companies as an undergraduate student, investigating the interface between engineering and medicine. The summer before her senior year, she noticed a university lab door with a sign that read "Artificial Organs." Intrigued by the name, Bhatia knocked on the door and implored the lab team to give her a position with them that summer, in what became a pivotal move for her career. Acceptance to the lab gave her the opportunity to work on a nerve regeneration project with Dr. Moses Goddard. Goddard, who became Bhatia's second mentor, discussed her future plans with her. As a senior, Bhatia planned to get a master's degree in engineering and then find a corporate job. Showing the same belief in her abilities as her father had when she was a teenager, Goddard encouraged her to get a Ph.D. instead. Goddard planted a seed, and although Bhatia took a gap year after graduation to work for a pharmaceutical company, she quickly realized that she needed deeper training to lead a biotech enterprise. Bhatia began applying to graduate programs two months into her industry job.

Process: From Intent to Impact

Bhatia draws energy from the opportunity to learn something new every day. Although she acknowledges that improving existing technologies is important, what has always inspired her is "blue sky inventing,": looking to fill empty, uncharted space. Bhatia began expanding beyond her comfort zone and tackling areas in which she had no previous knowledge early in her career, believing it is worth putting time and energy into bringing ideas to fruition.

In 1991, Bhatia left her industry position and entered a mechanical engineering master's program at MIT, one of only two women in her class. A Harvard-MIT Division of Health Sciences and Technology program allowed Bhatia to simultaneously pursue a Ph.D. in biomedical engineering and attend medical school, drawn to the latter by her love for the human body and its inner workings. She studied with her third mentor, Mehmet Toner, a biomedical engineer in Massachusetts General Hospital's department of surgery. Bhatia worked with Toner on finding a way to keep liver cells alive outside the body in order to make a machine, similar to a dialysis machine, for liver failure patients. Bhatia's goal was to figure out how to keep liver cells alive on a surface by patterning the cells on that surface, clustering them together and giving them another cell as a "friendly neighbor," a process known as microfabrication.

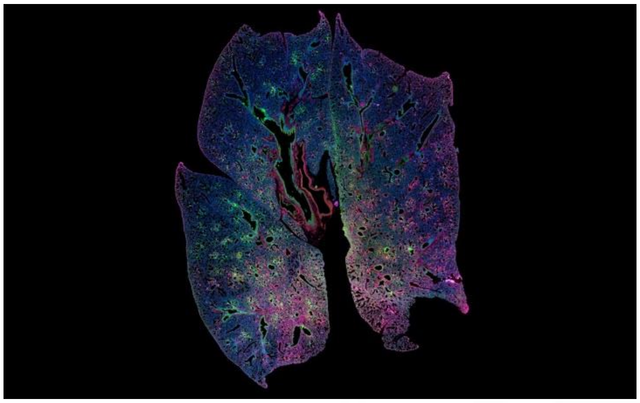
Bhatia took a different approach after her attempts to keep liver cells alive failed for the first two years. Looking outside her lab and into other disciplines, she took her now-husband's suggestion to visit an MIT computer chip fabrication building, since the pattern surfaces Bhatia was making used the same technology as computer chip fabrication. The facility at MIT had not combined biology and microfabrication, but she persuaded its operators to let her try some experiments. She finally arrived at an architecture of cells in patterns of stripes and dots that function like tiny livers. Toner realized they should file a patent describing how these cells could be stabilized in culture on the night of her Ph.D. defense. Her pioneering work and its successor models enabled Bhatia and her colleagues to study diseases that affect the liver and to investigate drug toxicity and metabolism.


Engineered human liver tissue. (Image/Chelsea Fortin)

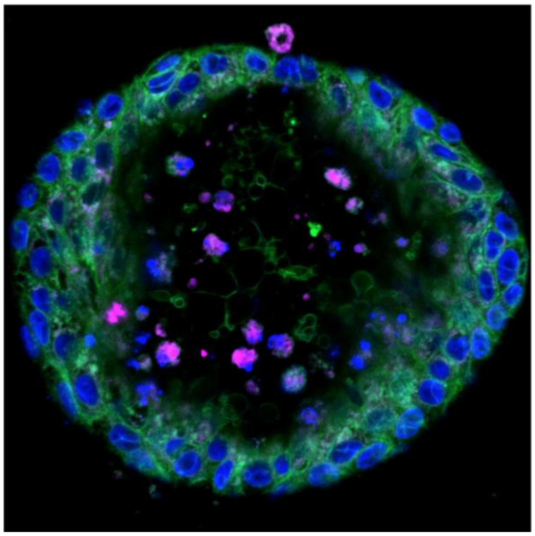
It became apparent to Bhatia that to have an impact she would need to commercialize her patent and mass produce, market, sell and disseminate a physical product. In 2008 she co-founded Hepregen, her first startup, to manufacture a microliver device and distribute it to pharmaceutical companies. She received initial funding from an incubator at MIT and then raised venture capital, which allowed the company to industrialize her invention and build a family of patents around it. In fewer than 10 years, more than 40 companies started using Bhatia's method to test drug safety in liver cells before moving to clinical trials, identifying issues that might otherwise not be caught that early.

Bhatia moved across the country during her final year of medical school to join the University of California, San Diego faculty, completing her fourth year of medical school while also working as a junior professor. At UCSD, she discovered that she preferred to work in the lab where she could improve systems and invent new tools. Microfabrication technology had advanced to making structures at the nanoscale by 2000, allowing the manipulation of not just cells, but also molecules and receptors on cells. Bhatia, armed with this new toolkit, began experimenting with getting these tiny materials into diseased tissues and improving medicine and health outcomes at individual and global levels.

The dean of engineering at UCSD introduced Bhatia to Erkki Ruoslahti, a biologist who had discovered how to put molecular zipcodes on materials. Together, they envisioned putting molecular zipcodes on nanoparticles—which are about a thousand times narrower than a human hair. Bhatia hired a postdoctoral student who knew how to make nanoparticles and collaborated with Ruoslahti on a research paper. Bhatia's team experimented with making nanomaterials of varied colors and applying different amino acid coatings on the surface that would direct the nanomaterial where to go. When they injected the nanomaterials into a mouse, they observed the nanocrystals lighting up organs in different colors, able to tell instantly that the nanomaterials went where they had directed them.



A slice through a mouse lung that was infected with bacteria and treated with therapeutic peptide-nanoparticles. The red color marks the bacteria, and green marks the therapeutic nanoparticles. The blue color marks the cells of the lung, and magenta marks the cells that form part of the body's own immune response to the bacteria. (Image/Ester J. Kwon, Matt Skalak, Sangeeta Bhatia)



Engineered nanoparticles penetrate and attack tumor cells to effectively treat pancreatic cancer. Blue coloring shows the cell nuclei, green the cell membrane, and magenta the nanoparticles. (Image/Liangliang Hao, Srivatsan Raghavan, Emilia Pulver, Sangeeta Bhatia)

This work led to yet another project. Bhatia's students noticed, while trying to make magnetic coatings on a different kind of nanoparticle for use in MRIs, that whenever the animal had a tumor the bladder lit up. They learned that enzymes on tumors were cutting off the amino acids on the surface of the nanoparticle, and the amino acids were finding their way into the urine. This discovery meant that patients could be screened for cancer or other diseases through a urine test using nanoparticles, eliminating the need for an MRI machine or other expensive equipment.

This invention exemplifies how Bhatia approaches her work with creativity, collaboration, and the recognition that inventions may arise unexpectedly. Bhatia's group, which could measure about 550 enzymes connected to almost every kind of disease, realized they could make panels to test 10 to 20 conditions at once. Bhatia co-founded Glympse Bio to take this technology to patients in 2015. The company announced data supporting the safety of nanoparticle-based biosensors in in-human clinical trials in late 2020. This type of nanoparticle screening—allowing for the replacement of clinical infrastructure for high-end molecular diagnostics with a pill and urine test—has huge implications for global health, especially in developing countries. The technology enables diagnosis for patients who otherwise might not receive answers or appropriate treatment. It could also help avoid overdiagnosis and unnecessary intervention when something that appears to be cancer is not.


Bhatia working with students. (Photo/Justin Knight)

Bhatia's innovating process is grounded in interdisciplinary teams that bring chemistry, physics, medicine and biology together. She is passionate about sharing and collaboration, viewing ideas as living organisms that evolve through exploring different perspectives and new approaches. Bhatia values three different types of contributions: advancing scientific knowledge that discovers something fundamentally new about the way the world works; medical contributions that may have no new scientific insight but help patients; and innovative technology, even if it may not be immediately useful. She understands that blending these contributions often leads to invention. Bhatia believes that there are intellectual "lightbulb" moments in invention, but also knows that deriving an impactful outcome from these moments — whether in the form of an invention, data package or startup — requires collaboration. Bhatia encourages others to bring their own ideas and relationships into invention, recognizing the importance of interaction between people with different skills and perspectives.

Bhatia inhabits a particularly rare role in the United States, where women make up only 12 percent of all patent-receiving inventors. Women own fewer than 10 percent of technology startups backed by venture capital, and women founders receive only 2.7 percent of all venture capital. Bhatia has pushed these boundaries, cofounding five startups by 2020 and serving as a founding adviser for a number of companies started by her students. Bhatia was elected to the National Academy of Medicine in 2020, becoming only the 25th person to be elected to all three national academies (Science, Engineering and Medicine). She started the Future Founders Initiative with MIT backing — a program that empowers and creates a network for female entrepreneurs — and serves as an adviser to the MIT Society of Women Engineers.

Bhatia giving a TED talk on nanoparticle science and her vision of a revolutionary new cancer test that could save millions of lives across the globe. (Photo/TED/Ryan Lash)

For Bhatia, raising awareness of unconscious bias against female researchers in hiring, promotion, and speaking opportunities is nothing short of an obligation. She passionately advocates for diversity in Science, Technology, Engineering and Math fields and strives to bring more women into STEM. She encourages and mentors girls to study science and engineering, from organizing the science fair at her daughters' elementary school to helping start Keys to Empowering Youth as a graduate student at MIT. Keys to Empowering Youth, which has expanded to other colleges, brings girls aged 11 to 13 to campus so they can see women training to be engineers and scientists while experiencing firsthand the exciting technologies used in the labs. Bhatia's tissue engineering lab is part of the program.

Only one out of 10 of Bhatia's colleagues is a woman. Consequently, the opportunity to provide a lab full of 11-year-old girls with role models and growing their awareness of STEM as a career path is a heartwarming gift for Bhatia. When they visit her lab, girls can touch artificial organs, see their own cells in the microscope, and have a CSI-style lab experience with spies, prototypes and nanoparticles. Bhatia stresses the importance of not just inspiring young girls, but removing systemic barriers that might prevent them from pursuing careers in STEM, citing studies that show the impact of role models on girls' career paths. Parental and public school encouragement also plays an important role, as does broader societal recognition and celebration of female achievement and respect for science among policymakers. As a scientist, engineer, entrepreneur and educator, Bhatia strives to help girls see what engineers can accomplish, drawing connections between the field and popular technologies like iPods. She also wants girls to see that they can make an impact and still lead lives outside of work.


Bhatia teaching. (Photo/Len Rubenstein)

Bhatia has also used her position as an engineer, scientist, entrepreneur, and educator to mentor her students to become independent thinkers. She creates an environment that fosters teamwork, collaboration and exploration, setting aside 20 percent of her students' time to work on their own projects. As a self-proclaimed collector of mentors and sponsors — including her father, Goddard, Toner and Robert Langer, an unofficial mentor who has inspired and championed her — Bhatia believes that mentorship is a career-long process, from the earliest stages to embarking on that profession.

In Bhatia's current work, students embarking on their professions work in her lab. She approaches this like an apprenticeship, teaching her students how she learned to approach problems and curiosities. Most mentorship centers on a piece of original research. Bhatia guides her students as they consider their career paths, talking with them about becoming a professor or going into industry or policy, and helping them with introductions and recommendations. She has created a family culture in her lab, to the extent that her chief of staff is fondly considered the “lab mom.” Bhatia encourages her group to learn from each other, believing “the way we work is as important as the work that we do.” Drawing on her own commitment to service, she tries to give the students she mentors the sense that they are not individual actors but part of a scientific community, which is important and a privilege, and they have to pay it forward.