Sanjiv 'Sam' Gambhir (1962–2020)

On 18 July 2020, the nano community lost a pioneer and visionary. Sadly, Dr Sanjiv 'Sam' Gambhir passed away due to complications with his fight against cancer. He was a loving son, brother, father and husband adored by his family and friends and remembered as someone who embodied the virtues of kindness, empathy and love.

Dr Gambhir was the Chair of the Department of Radiology at Stanford University and held the Virginia and D. K. Ludwig Professorship for Cancer Research. Chairing a massive clinical department while running an active research lab with more than 30 members was no small feat, but Sam was known for his legendary work ethic. He spent his life identifying compelling clinical problems and attempting to solve them. His hope was to impact how medicine was practiced today, but also to lay a foundation for transforming medicine a hundred years from now.

Sam graduated with a bachelor of science degree in physics summa cum laude from Arizona State University. He then completed his PhD in biomathematics, his MD and his nuclear medicine fellowship at the University of California, Los Angeles (UCLA). This interdisciplinary training shaped Sam's unique prowess for envisioning how nascent technologies could impact medicine.

Sam was a founding father of molecular imaging, a field developing approaches to reveal important physiological characteristics of a living system, often before the occurrence of anatomical structural changes. He firmly believed that molecular imaging coupled with in vitro diagnostics could improve early cancer detection and enable personalized treatments for better patient outcomes.

Sam's nanomedicine journey began in the early 2000s, during his first faculty position at UCLA. Conversations with Dr Jim Heath, head of the California Nanosystems Institute, sparked an interest in nanotechnology. Shortly thereafter he met Dr Shimon Weiss, a recent UCLA hire and quantum dot expert. Sam immediately realised that these fluorescing nanoparticles could lead to new ultra-sensitive molecular imaging approaches. Dr Jianghong Rao, a close collaborator at UCLA and Stanford University, recalls Sam's initial excitement about the potential impact of nanoparticles on molecular imaging. Dr Rao explains, "Sam had that amazing talent in seeing the future. He saw the important role nanoparticles would play in the fight against cancer and had a roadmap to bring nanotechnology to molecular imaging."

Credit: Steve Fisch/Stanford Medicine

Soon after his move to Stanford, The National Cancer Institute launched the Centers for Cancer Nanotechnology Excellence (CCNE). The CCNE initiative was catalytic for Sam, both fuelling and enabling his interest in bringing nanotechnology into the clinic. Dr Piotr Grodzinski, the programme officer for the initiative, remembers Sam fondly: "he was a creative and prolific scientist, but also a great strategist, and great leader". Nowhere was this more evident than in his development of Stanford's CCNE. New to Stanford, Sam was introduced to Dr Shan Wang, a Professor of Material Science and Electrical Engineering who would become his co-principle investigator and long-time collaborator. Together Sam and Shan built a team of 40 investigators spanning 14 disciplines from multiple departments at Stanford, UCLA, Cedars-Sinai, the Fred Hutchinson Cancer Center and the University of Texas at Austin, with industry partners from GE Global Research and Intel Corporation. The centre was built around Sam's vision for nanotechnology transforming in vivo and in vitro diagnostics; magneto–nano sensors, nanotube/nanowire sensors, Raman nanosensors and quantum dots were brought together to enable personalized medicine.

The CCNE significantly impacted the composition and research trajectory of Sam's lab. Stimulated by interactions with nano researchers across the world, Sam engendered diverse clinical applications for nano-based imaging contrast agents. One of Sam's earliest *Nature Nanotechnology* papers, was the first to describe a photoacoustic imaging approach that used targeted carbon nanotubes to image tumours in animals. More recently, looking for an imaging strategy that could interrogate multiple molecular entities simultaneously, Sam devised a Raman-based technique that used gold–silica nanoparticles as contrast agents to enable, for the first time, the measurement of 10 separate spectral signatures in a single image. He envisioned its clinical translation by way of endoscopy, adding a functional imaging accessory to the clinical endoscopes already used to screen the colon and filed for US Food and Drug Administration approval to use these nanoparticles in humans.

Those who attended his lab meetings remember his passion for learning. He often shared new ideas he had concocted after watching a NOVA special. He encouraged his lab members to take note of even the smallest details, to never stop learning and to casually read research articles 'for fun' on the weekends.

Under Sam's direction, the CCNE produced more than 600 nano-related publications. In addition, Sam emphasized how critical it was to not just develop technology, but to shepherd its clinical application. With this in mind, Sam made sure that the CCNE's research efforts were paralleled by commercialization efforts. Stanford's CCNE has generated more than 60 patent filings, numerous US Food and Drug Administration applications and over a dozen successful companies. A huge proponent of fostering the next generation of researchers, Sam also ensured that Stanford's CCNEs had a training and outreach component that helped groom hundreds of students and post-docs. Several have now started their own nano-focused research labs as academic professors across the world; a legacy he was truly proud of.

The future Sam envisioned decades ago is here today. Sam has been a catalyst for the development of powerful nanotechnologies for cancer detection and imaging. Dr Wang described his greatest contribution as "forging a close relationship between the medicine and nano communities", and added "Before Sam, people were saying

that nano could be used in medicine. Sam's efforts helped the field blossom and we can now say that nano is being used in medicine."

Dr Joe DeSimone, CCNE director at the University of North Carolina recalls having extraordinary conversations about translational science with Sam, which is fitting as Dr DeSimone has recently joined Stanford University as its first 'Sanjiv Sam Gambhir Professor of Translational Medicine'. His sentiments capture Sam perfectly: "He epitomized excellence in translational medicine through his vision, leadership, execution and unwavering persistence. There was no one like Sam. He was an incredible scientific visionary, pioneer and person." ❐

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