How curiosity sparked pioneering cancer research

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"I did this research by chance. I was enrolled at the Koch Institute for Integrative Cancer Research at MIT for my postdoctoral work to develop electrical devices with biotechnology. The institute is focused on cancer

research and I happened to view other groups' work on cancer cells. I thought, 'This is quite interesting', and wondered if I could extend my work to cancer research," said Assistant Professor Desmond Loke at the Singapore University of Technology and Design (SUTD).

Asst Prof Loke's primary expertise lies in electrical and computer design. Throughout his Ph.D. and postdoctoral studies, he worked on phase-change memory and led a research team that revolutionized the use of bacteriophages to improve the performance and capacity of this technology in computer storage. His research has earned him various awards, including the 2018 MRS Innovator of Materials Science Award and the 2016 Global MIT Technology Review Innovators Under 35 Award.

While working alongside the cancer research groups during his postdoctoral studies, he became intrigued by the possibility of extending the application of his electronic devices to cancer studies. More specifically, he became interested in making cancer detection and treatment more effective. When he joined SUTD in 2016, he created the Loke Bio-nanotechnology & Electronics-for-Large-scale Lab (LBELL) to delve into this research area.

"That's why I started this lab—to explore new types of cancer cell sensors and cancer therapy using viruses in our electronic devices. I got interested in this area by chance because I actually saw excellent cancer technology and research at MIT," he explained.

The power of cross-disciplinary research

As the name implies, LBELL conducts research in two broad fields: bio-nanotechnology and electronics. Asst Prof Loke guides and leads postdoctoral researchers and graduate students in cutting-edge research across different areas, from memory technologies to artificial neural

networks to electronics for biomedicine.

In bio-nanotechnology, among the lab's notable works is a highly sensitive cancer cell sensor developed using two-dimensional (2D) materials. Combining molybdenum disulfide (MoS_2) nanosheets with a bioelectrical signal processing system, Asst Prof Loke demonstrated a sensor that can detect the bioelectrical signals of cancer cells in a single setup with greater speed and sensitivity than other biosensing technologies. This breakthrough study indicates the potential of 2D materials in improving the early diagnosis of cancer cells.

In more recent research, Asst Prof Loke is pioneering the use of the 2D material-based bioelectrical signal processing system in cancer ablation. One emerging method to ablate cancer is electrothermal therapy, which applies nanomaterials to the targeted cancer cells to allow electric current to pass through as well as heat up and destroy the cells without affecting surrounding tissues. However, the conventional nanomaterials used do not always produce sufficient Joule heating to ablate the cells effectively.

To overcome this limitation, Asst Prof Loke added an M13 bacteriophage on MoS_2 nanosheets and created a novel nanomaterial that binds better to cancer cells and has stronger electrical conductivity. The resulting nanomaterial was shown to reduce the number of pancreatic cancer cells two times more than conventional nanomaterials during electrothermal therapy.

"The bioelectrical signal processing systems built around the advanced 2D material could be harnessed for a broad range of medical applications, from tumor ablation to cardiac arrhythmia treatment to neuromodulation. The adaptability of the system suggests its potential wide applicability," said Asst Prof Loke.

Persevering against all odds

The interdisciplinary nature of the research carried out at LBELL is what makes the lab unique and innovative. Yet, not everyone thought such research to be possible at first.

"You're an electrical designer, how can you make a biologically based device? You can't."

"You're in one department. Where would you locate a lab to perform these two tasks?"

These statements reflect the initial skepticism that Asst Prof Loke faced when he proposed the idea of extending his expertise in computing and electrical design to cancer research. There were many doubters and naysayers, according to him.

"Initially, it was very difficult. Since we didn't have a lab, we decided to create a special lab—a combined bioelectrical lab—at SUTD. Inside the lab, we have a standard facility for cell culture and, at the same time, new tools and equipment for electrical study. So this lab should be able to carry out not only regular biological work, but also advanced electrical testing," Asst Prof Loke described.

Setting up a facility that could realize Asst Prof Loke's vision was one of the main challenges. Everything in the lab had to be custom-prepared and specially built. Yet, Asst Prof Loke was undeterred as his curiosity drove him towards his goal. The interdisciplinary nature of the lab might be unheard of, but he believed in the direction that his interest was taking him.

He also received excellent support from SUTD. "We had great assistance from the university managers and my colleagues. They supported our

interdisciplinary research and helped us in building the necessary platform to conduct it," he stated.

In the end, he credited much of the success to his good fortune in finding researchers who share his vision and are interested in interdisciplinary work.

"The next step after creating the lab was to get people to join it, and I was lucky. I have very fantastic team members with different research backgrounds who are hardworking, courageous and adventurous to pursue this idea. Natasa Bajalovic, Maria Meivita, Denise Lee, Sophia Chan, Fitya Mozar—these are just some of the outstanding members in the team," he said.

With the advent of next-generation artificial intelligence, Asst Prof Loke foresees an exciting future as he continues to forge ahead with promising research, be it in the areas of computing or biomedicine. For his cancer research, he looks forward to moving from small-scale laboratory studies to exploring a larger type of cancer cell system and partnering with hospitals to carry out clinical studies.

Provided by Singapore University of Technology and Design

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