Engineering Cancer Solutions

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The fight against cancer is never ending. Across the globe, the finest scientists and researchers struggle to stay one step ahead of the deadly disease, which claims hundreds of thousands of American lives each year. But although the battle is not yet won, significant progress is being made in labs and classrooms right here at UT Arlington.

In the lab of Jenkins Garrett Professor J.-C. Chiao, prostate cancer gets the spotlight, as he and his colleagues work to develop a device that can assess cancer risk. Meanwhile, a few doors down, bioengineering researchers are busy building a nanoparticle-based drug delivery system that could help reduce the devastating side effects of chemotherapy. And in the Electrical Engineering Department, Samir Iqbal has found a novel use for silicon chips as a cancer detection device.

As their work will show, the war on cancer is a cross-disciplinary, collaborative endeavor. The National Cancer Institute estimates that about 1.64 million new cases of cancer will be diagnosed in 2012. For a fight this large, all hands are on deck.

Predicting Cancer's Next Step

To tackle a disease as prevalent as prostate cancer, Dr. J.-C. Chiao, an electrical engineering professor, knew he’d have to get to the heart of the danger—metastasization. So he and his team developed a microfluidic device that can assess the risk of metastasis in patients due to cancer cell migration, a major cause of death.

Called MMIC (Microfluidics for Migration of Cells), his device uses prostate cancer patients' own blood to determine this risk. In an attempt to replicate human blood vessels found in bone, it has microscopic tunnels that allow cancer cells to travel between two chambers. A very small drop of patient serum is placed in one chamber and prostate cancer cells are placed on the other side. Researchers then observe the sample to see how fast the cancer cells move toward the serum.

"Our pilot study shows amazing results. We took blood from patients who have metastasis and from healthy men, and found that we can predict with 85 percent accuracy which samples induce metastasis," Chiao says. "The study is all done..."
outside the body with a tiny drop of blood. It’s not painful."

The next step for the researchers is to test chemotherapy drugs outside the body using the MMC assay to determine which ones effectively stop metastasis. Chemotherapy often has negative side effects for patients and may not be guaranteed to stop metastasis. By being able to test different drugs outside the body, doctors could adjust patients’ therapy to make sure the patients receive the most appropriate chemotherapy without having to inflict unnecessary side effects on them.

Chiao and his collaborators—Kytaï Nguyen from the Bioengineering Department, J.T. Hsieh from the Urology Department of UT Southwestern Medical Center, and Alfred Distefano from the Texas Health Resources Arlington Cancer Center—believe the device is a step toward personalized medicine, as it not only can help doctors assess the risk that a patient may develop metastasis, but also tailor the therapy to the individual patient.

“If we are able to predict if the patient has any factors in their blood that promote metastasis, we can help the doctor to decide a treatment strategy,” Chiao explains. “If there’s no risk for metastasis, you don’t necessarily want to give chemotherapy. If there is possibility for metastasis, the doctor can use the technology to find the right drugs that will work best.” The research team has also tested its device with breast, lung, and kidney cancers, to promising results.

“I can envision a future where this technology is refined into a piece of desktop equipment in a clinic that enables staff to regularly monitor patients during their visits.”

**Improving Chemotherapy for Patients**

As Chiao’s research demonstrates, despite its benefits, chemotherapy treatment also has many drawbacks. But Kytaï Nguyen wants to change that. The bioengineering associate professor is developing a cancer cell-selective nanoparticle system that can be targeted for imaging and drug delivery to detect and cure prostate cancer.

She and her team—which includes former Associate Professor Jian Yang, Ph.D. student Ankit Wadajkar, and Professor Hsieh of UT Southwestern—has invented nanoparticles that have a magnetic core covered by a fluorescent, biodegradable polymer shell. The core is useful for magnetic targeting, MRI imaging, and producing induced heat for hyperthermia. A magnet is placed on the skin near the affected area to draw the nanoparticles directly there, thus making imaging easier and facilitating better drug delivery. Meanwhile, the biodegradable photoluminescent polymers serve both as a drug carrier and an optical contrast reagent, allowing researchers to detect cancer cells more easily.

"Some drugs are very toxic. We want to kill cancer cells, but we often kill healthy cells, too. If you deliver chemotherapy drugs to the whole body, you will have negative side effects, such as hair loss and fatigue,” Dr. Nguyen explains. “But if you can load these nanoparticles with medicine and deliver those drugs directly to where they’re needed, you can lessen these. Plus, we have found that the nanoparticles attack cancer cells more with a magnet than without.” In Nguyen’s lab, the team has successfully created a particle with a polymer created by Dr. Yang and a peptide created by Dr. Hsieh that will attack prostate cancer cells and not harm healthy cells.

The nanoparticles are unique and can address the current challenges in prostate cancer management, and may also help treat breast, skin, thyroid, and other cancers. What’s more, the nanoparticles can be used several times and allow adjustments to the drug load to improve therapeutic efficiency. And since the photoluminescent
polymers are biodegradable, they are eliminated from the body once they are no longer useful for treatment.

**Finding Treatment in New Places**

Like Chiao, Assistant Professor Samir Iqbal is also working on cancer metastasization, but his research has found inspiration in an unusual source: cellphones. The silicon chips used in those and many other electronic devices, it turns out, can be repurposed to identify cancer cells in a patient's blood stream long before they metastasize and become deadly.

The chips, in fact, act as mouse traps for cancer cells. Using a new class of molecules called aptamers, which were developed by a chemist at UT Austin, Dr. Iqbal has created a surface that increases trapping efficiency. Rogue cells come in contact with the surface and don’t want to leave, but healthy cells won’t bind with it because they see it as a foreign object. "With this technology, doctors will no longer have to wait for the physical symptoms of cancer to appear before beginning treatment. Rather, they can detect the presence of cancer cells early and stop metastasis," Iqbal explains.

"Diseased cells have a lot going on that's different than normal cells. When cancer starts, it's hard to find because there's a very small concentration of cells. The tumor cells also travel through the bloodstream searching for other organs that they can invade."

In older detection systems, the blood sample had to have at least 1,000 cancer cells per million. But Iqbal’s new surfaces can be effective while trapping far fewer cells, allowing him to confirm cancer with 10 cells per million. The researcher's goal is to be able to detect cancer during a patient's annual physical, a time when it may be early enough to be isolated and cured.

"We are defining a test that can detect cancer cells in the blood very early so we can find out if there is a site shedding scout cells and if a distant site somewhere else in the body," he says. "That way, doctors can focus on treating the primary site as well as preventing the cancer from spreading."

The electrical engineer believes his research may have a global reach. Smokers, for example, often smoke for years without cancer symptoms, but a simple blood test that can detect the presence of cancer early on could save lives and millions of dollars in medical costs. One other byproduct of Iqbal’s research is an increase in collaboration with researchers both inside and outside the University, something that he relishes.

"The College of Engineering and the University have fostered a collaborative environment," he says. "I've been working alongside doctors from UT Southwestern and the Arlington Cancer Center. Before, I never saw oncologists visit our campus. It's an enabling factor that we don't have to 'defend our turf' and it's a credit to the University's vision. It's a new era at UTA."