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Charting Internal Maps

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Charting internal maps

Exclusive biomedical instrument capable of safely imaging animal physiology set to advance medical treatments
Don’t let their beady eyes, large incisors and tail fool you: Rodents may hold the keys for medical breakthroughs in treating cancer and other infectious diseases in animals and humans.

That’s the focus a team of chemists, veterinarians and an electrical and computer engineer at Kansas State University are taking in a multidisciplinary approach to biomedicine. The researchers designed a one-of-a-kind biomedical instrument that heats specific cells in the body using a process called radiofrequency hyperthermia, which mimics how the body uses fever to fight infections. As the targeted cells are heated, the instrument produces high-resolution images of cells and internal organs. This enables researchers to monitor the heat’s effects on inflamed cells and tumors in real time.

“By applying hyperthermia to a specific area of the body, we can really see what’s happening at a very fine cellular level,” said Stefan Bossmann, professor of chemistry and project lead. “When we see the physiological effect and heat distribution pattern in real time, we can tailor our techniques accordingly as we treat small animal patients with infections, cancers and other diseases.”

Those small animal patients receiving personalized biomedicine will be rodents.

As the rodents are treated of their diseases, the techniques and information will be applied to help larger animals with similar illnesses. The research also may usher in personalized hyperthermia treatment for humans, Bossmann said.

High-tech approach

The National Science Foundation’s Major Research Institute is funding the $1.9 million biomedical instrument — a modified wide-bore 600-megahertz magnetic resonance imaging spectrometer with a custom imaging probe. Because it is the first of its kind, parts are being crafted in Switzerland and France before the device is assembled in Germany and then shipped to Kansas State University.

Leila Maurmann, nuclear magnetic resonance/instrumentation manager in the chemistry department, will oversee the instrument after its installation at the university.

Rodents up to the size of a guinea pig are put inside what looks like a small spaceship, which is filled with air and an anesthetic gas so that they fall asleep. The craft travels up an elevator of compressed air and into a chamber of coils. The coils and custom imaging probe scan the rodent and computer software maps the rodent in 100-by-100 micrometer sections to produce a 3-D voxel-based image of the body, internal organs and any tumors.

Rodents are not harmed at any point in the process or the exam.

The instrument’s software is being written by Punit Prakash, an assistant professor of electrical and computer engineering who researches radiofrequency hyperthermia. He also is developing the unique magnetic resonance imaging probe that makes it possible to produce high-resolution images and conduct targeted thermal cell therapy at the same time.

Studies with the device are expected to begin in October.

Divide and conquer

Deryl Troyer, a professor of anatomy and physiology who specializes in developmental defects and stem cell biotechnology, is collaborating with Bossmann and others on using hyperthermia and nanoparticles to treat cancer. Stem cells from the Wharton’s jelly of umbilical cords as well as defensive cells are used to cloak magnetic nanoparticles and traffic them to tumors. A radio-frequency field heats the nanoparticles, overheating the tumor and killing it.

“The key is that as we get feedback from the instrument, we can fine-tune it and refine this treatment method to a greater extent,” Troyer said.

Sanjeev Narayanan, associate professor of diagnostic medicine and pathobiology, will use the instrument to help treat the infectious disease Fusobacterium necrophorum — a bacteria that causes necrotic lesions on cattle’s livers and causes cattle to grow more slowly.

A more deconstructed system that uses radio-frequency antennas to generate a similar analysis will be built for use on cattle and other large animals in the field.

Additionally, Bossmann said the instrument’s hardware can be adjusted so that researchers can work with heart disease and other cardiovascular diseases.

“With this technology we can then start building integrated therapies,” Bossmann said. “We have heat therapy, chemotherapeutics, can recruit defensive cells, and now will have an integrated piece of equipment that will be a springboard to do integrated therapy using these methods. There is no golden bullet to make advanced infectious diseases and cancer magically go away. They are systemic diseases and they have to be beaten with systemic methods.”

According to Bossmann, the project’s interdisciplinary approach — from construction to conducting research — is imperative to success with the biomedical instrument.

“It starts the dialog and teaching of a common language that researchers can take back to their departments and translate for others in their discipline,” Bossmann said. “For example, Deryl can talk to the veterinary medicine researchers and explain the project in their language and I can do the same with the people in chemistry. This allows us to get third parties in faster because we can translate to different groups of people.”

— By Greg Tammen, Division of Communications and Marketing