The Inside Story at Stephenson

By Debra Levy Martinelli

Perhaps the best-known research unit housed in the Stephenson Research and Technology Center on OU's Research Campus is the Advanced Center for Genome Technology, which is practically synonymous with its director, biochemistry professor Bruce Roe. Designated since 1990 as a Genome Center by the National Institutes of Health, National Human Genome Research Institute, the ACGT was one of the first three laboratories involved in the worldwide Human Genome Project. Since then, its research team has mapped the first completed human chromosome—chromosome 22—and in the process discovered genes involved in several forms of brain cancer, leukemia, mental retardation and schizophrenia. ACGT's current research covers vertebrates (mice, chimpanzees, baboons and zebrafish) to plant life (alfalfa, soybeans, and plant and grass fungi).

Roe draws on the expertise of several fellow Stephenson Center dwellers, including Han Wang, assistant professor of zoology and an expert on the genetic development of zebrafish; Tyrrell Conway, professor of molecular microbiology and functional genomics and director of OU's Microarray and Bioinformatics Core Facilities; and Randy Hewes, assistant professor of zoology, each of whom brings to the Genome Center valuable knowledge that flourishes within the unique collaborative environment.

Wang's work with the tropical zebrafish is directly related to the function of human genes.

"Of the 25,000 genes in the whole human genome, about 1,000 are predicted on chromosome 22, but scientists know the function of only about 250 of those 1,000," Roe explains. "Zebrafish and humans share 90 percent of their genes. But while genes in a human embryo are expressed in maybe weeks seven to 10, in a zebrafish embryo they are expressed over a period of only a few hours. That's where Dr. Wang's research comes in."

Wang's Stephenson Center laboratory contains some 1,500 tanks holding nearly 10,000 zebrafish. His team can produce up to 3,000 to 4,000 embryos daily. "The embryos are transparent, so we can watch them develop, which takes only a day. The zebrafish heart, brain and blood cells resemble those of humans. Because the genes are similar, when we alter the gene of the fish, the organ will become malformed and may be similar to human diseases. So we model these diseases and use this fish to study them," he says.

Hewes, meanwhile, uses the laboratory favorite fruit fly as a genetic model to research small proteins called neuropeptides, which are released by nerve and endocrine cells and play important functions in regulating neurocircuits in the brain and coordinating functions of the brain and other tissues. Because the fruit fly develops from egg to adult in 10 days, he can conduct sophisticated genetic studies in a short period of time.

"Many of the features of cells are conserved throughout evolution," he explains. "So if I am looking at secretion of neuropeptide in a fly, I am looking at the same processes that are used to secrete neuropeptides in humans. If I understand some central aspect of that, it may inform our understanding of how this is done in humans."

In a nearby Stephenson Center lab, Conway directs the OU Microarray and Bioinformatics Core Facility, which provides Roe, Wang, Hewes and countless other researchers with the power-

At Home in SRTC

The Stephenson Research and Technology Center houses the following programs:

- Advanced Center for Genome Technology, where OU researchers have sequenced the first completed human chromosome;
- Institute for Environmental Genomics, where scientists explore microbial genomics and ecology;
- OU Bioengineering Center, where engineering principles are applied to challenges in medicine and biology;
- OU Microarray and Bioinformatics Core Facilities, which offers the powerful tools of the highly complex technology of functional genomics to OU researchers;
- OU's Supercomputing Center for Education and Research, or OSCER, which provides supercomputing education, expertise and resources to the University community;
- Neuroendocrine Development Genetics Lab, whose scientists study neuropeptides, which play important functions in regulating neurocircuits in the brain and coordinating functions of the brain and other tissues;
- Robotics, Evolution, Adaptation and Learning Lab, where researchers develop robotics applications for space exploration, military operations and medicine;
- Zebrafish Development, Genetics and Genomics Lab, where researchers study the genetics and genomics of zebrafish, which have genes similar to those of humans.

ful tools of functional genomics.

"The genes of humans are almost identical, so just knowing the sequences doesn't explain why we are individuals," Conway explains. "What makes us unique is the level of expression of each of those genes during development and also in response to insults like disease. We each respond differently and have varying susceptibility to diseases. All of that is part of our genetic makeup."

Researchers can measure the gene expression levels with a cutting-edge technology called microarrays—or genome chips—that are thousands of genetic material "spots" typically less than 200 microns in diameter. An experiment with a single genome chip can provide researchers information on thousands of genes simultaneously. Conway discovered the need for a database to manage that "landslide of data" and has spearheaded creation of both a bioinformatics infrastructure for the state of Oklahoma and a database for microarrays.

The technology allows Conway and others to monitor gene expression in a straightforward fashion within a single experiment and compile a comprehensive database with virtually endless capabilities. "Imagine a database that can give the history of the diseases you have had. If you are susceptible to a certain disease, and you come down with it, you want to know the prognosis and best treatment. This is the kind of information we think is locked into the gene expression profiles that you get with these microarrays."

On the ground floor of Stephenson Center, another group of faculty and students are dedicated to a topic that once was the exclusive domain of science fiction: robotics.

In the AIR (Artificial Intelligence Research) Laboratory, experts in computer science as well as electrical, mechanical and industrial engineering converge in true collaborative fashion to design and build robots that can assemble, manipulate and transport other objects and can even play soccer.

Dean Hougen, assistant professor of computer science and founder of the lab, focuses on the intelligent connection between sensing and action, which enables robots to expand their horizons beyond such tightly controlled environments as factories to find uses in military endeavors, medical and assistive applications, space exploration and elsewhere in our everyday lives. For example, with funding from the U.S. Army Research Office, Hougen's team is developing robots that are better able to conduct surveillance, reconnaissance and battlefield assessment.

In related research, Hougen is exploring the development of robotic teamwork. "A ground-based robot can see what is immediately in front of it, but doesn't have the ability to know the global picture of what the environment looks like," says Hougen. "It can't plan the best path to get from Point A to Point B because it doesn't know what is between the two. But if we team it up with other robots that are exploring the environment, they can share the information they are gathering with one another."

Photo provided

Chuck Saint is one of many undergraduates who gain hands-on experience in the center's artificial intelligence lab.

One way his Stephenson Center group is trying to improve robots' team performance is by engaging them in the specific tasks of soccer. "It's not clear at any given point during a game what the best strategy is. How strongly should you push the offense? How much do you guard against goals? Are you are trying to control the ball? How close do you keep it to yourself and how far should you kick it out in front as you run? You can have the robot learn these things. You can reward it when it earns goals and punish it when it fails," Hougen explains.

Computer science associate professor Andrew Fagg, one of Hougen's lab mates, wants to teach robots to make decisions and perform tasks on their own. "We're already putting them on planet surfaces [such as Mars rovers Spirit and Opportunity] but would like to have much more capable robots be able to go to Mars a few years before humans arrive to build habitats for them. In order to do that, though, robots can't just be passive with cameras and sensors. They'll have to be able to assemble and manipulate things."

To that end, Fagg and his team are working with the Johnson Space Center to develop control systems structured like human hands that can be controlled by a person and have a built-in automated system as well. Not only would the system be used in space for assembly and maintenance work but could also be called into service for more elaborate functions, including rescue missions, which are still handled by humans. Using the automated robots, Fagg says, would save time and, ultimately, human lives.

Back on Earth, both Hougen and Fagg believe home vacuum cleaners and lawn mowers are just the beginning of many applications of robotic systems that will become commonplace. "There's a lot of momentum building behind humanoid-style robots to perform a whole range of tasks rather than one or two," Fagg says. "And we're making good progress."

Much of these discoveries and inventions already are benefiting the state, nation and humankind in general. With the help of OU's Office of Technology Development, technology created through collaborations at the Stephenson Center is transferred to the marketplace.

"Faculty love discovering knowledge, but they also have an interest in seeing that knowledge put into practice," says W. Arthur Porter, University vice president for Technology Development. "They may want to establish their own spin-off company or license their inventions to existing companies. Whatever their interests, we provide opportunities to help make those things happen."