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Unlocking the genetic secrets of arthropods

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Unlocking the genetic secrets of arthropods



How one professor's work to decode insect physiology could improve human health and welfare



Michael Kanost

It's difficult to find much unused table space in Michael Kanost's office. The university distinguished professor and head of the department of biochemistry has nearly all of it claimed by stacks of folders and papers containing published and pending journal articles, grant proposals, project notes, research data — and jars filled with hundreds of live beetles.

It's an odd, somewhat startling combination to new visitors. But to Kanost, paperwork and bugs go together like peanut butter and jelly.

"I've always liked insects, and right now in my laboratory we're working on three different insect-biochemistry projects," said Kanost, who navigates the desk space with the expertise and finesse of a skilled musician whose fingers know every inch of the instrument.

A fellow of the American Association for the Advancement of Science, Kanost has helped uncover answers to questions about insects' biochemistry that have eluded scientists since the 1940s.

In 2005 Kanost was a member of a small research team that discovered that silencing the enzyme laccase-2 in a beetle prevents cuticle tanning, the process of hardening and pigmenting the insect's exoskeleton. A hardened exoskeleton keeps insects safe from chemical and biological injuries. Weakening it opens up the possibilities for pesticides. Understanding the exoskeleton's chemistry may also help develop ideas and methods for future synthesis of durable and lightweight materials for aircrafts, prosthetics and military armor.

Kanost took over the lead administrative duties in the department of biochemistry nine years ago when he was promoted to department head. The role requires him to know about the projects his colleagues, postdocs and graduate students in the department are working on, as well as manage the department's teaching, budget and personnel. Though these responsibilities leave little time to do experiments, Kanost leads three entomology-focused biochemistry projects that range from the immune system to metabolism. As the principal investigator, he contributes to formulating experiments, data analysis and serving as the lead author on many of the journal articles published on their findings.

Kanost began taking an interest in science in grade school, but he wasn't introduced to entomology, the study of insects, until he attended Colorado State University. What followed has been an intellectual pursuit that's spanned more than 30 years.

"Insects are really interesting because there's so much variety that occurs in this huge group of animals," he said. "Ultimately we want to understand them better."

Understanding this physiology could lead to advances in human health and welfare — including controlling diseases, curbing insect-caused crop loss and developing new durable, lighter-weight medical equipment and prosthetics.

The longest running of the three projects investigates insect immunity.

“Ordinarily an insect’s immune system would kill an invading microorganism,” Kanost said. “But under the right circumstances diseases can avoid or disrupt the insect’s immune response.”

To circumvent this ability to fight disease, Kanost and the others are looking at how the biochemical and cellular processes trigger an insect’s immune system response to pathogens and parasites. Work centers around proteins in the insects’ blood that participate in the immune system, giving insects protection against diseases. Once this process can be understood, it could allow scientists to develop an insecticide that targets an insect’s immune system rather than the central nervous system, Kanost said. In turn, this would make insects, like the malaria-carrying mosquito *Anopheles gambiae*, susceptible to the very diseases they transmit.

Most of the experiments for this immunity project use the tobacco hornworm, *Manduca sexta*. The large caterpillar provides good amounts of blood for biochemical analysis. A collaboration with Baylor Human Genome Sequence Center at Baylor College of Medicine is using DNA collected at Kansas State University to sequence the caterpillar’s genome.

“We’re very excited to help lead the sequencing of the *Manduca* genome, which will be extremely important for identifying genes of interest for future studies,” Kanost said. “This caterpillar is a model insect species for many projects in insect biology all over the world, especially for neurobiology. Obtaining its genome sequence will be immensely beneficial for understanding many facets of insect molecular science.”

Another project continues the study of exoskeleton and cuticle formation. The current focus, however, is on the biochemistry of cuticle protein cross-linking, which is responsible for the unique physical properties of insect exoskeletons.

“The exoskeleton of an insect has different properties depending on what stage of development the insect is in and what part of the body it is,” Kanost said. “For example, a caterpillar has a soft, flexible cuticle. Beetles have a mostly hard, stiff cuticle — except for some

regions that are more soft and flexible, such as the hinges between the connections, which are between the body segments.”

As a way to study the different cuticles that arise from protein cross-linking, the team is examining the wings of *Tribolium castaneum*, or the red flour beetle. Beetles are unique in that they have a modified wing that acts as a hard outer shell, covering the more typical insect wing set that’s used for flight.

Because the *Tribolium castaneum* genome has been sequenced, all of the insect’s genes are known. This allows researchers to predict which ones are responsible for making cuticle proteins. Testing for the right genes involves microarray experiments, which provide information about the messenger RNA expression for all of the genes. Proteomics are then used to identify all of the proteins present in samples taken. The combination of experiments tells researchers which cuticle protein genes are made in which part of the insect’s body, narrowing the search.

More recently the researchers started a third project that looks at insects’ metabolic uptake of iron. Copper-containing oxidase enzymes are the focal point for the study. These enzymes are thought to be connected with iron storage and transport throughout the insect’s body. This may be particularly important in mosquitoes, which have to deal with large amounts of iron in their system after they feed on blood.

Kanost has helped secure nearly \$16 million in funding – and on \$9.8 million of that total he served as the principal investigator. He has brought grants from the National Institutes of Health, National Science Foundation and U.S. Department of Agriculture, among others. Today the Kanost lab is regarded as one of the premier laboratories conducting research on insect immunity.

“I’m proud to lead a very talented group of undergraduate and graduate students, postdoctoral research associates and research assistant professors in my laboratory,” Kanost said. “The hard work and creativity of this team make it possible to push for exciting new knowledge in insect biochemistry. For our group, making discoveries about how insects work is a great joy.”

Understanding the complexities of an insect’s physiology at the molecular level is only one of Michael Kanost’s passions carried over from childhood. The other is music.

For nearly 40 years Kanost has played the cello, joining and performing in orchestras throughout his college and postdoc days. Four years ago he joined the Salina, Kan., Symphony. And while music and biochemistry seem polar opposites, Kanost said the two are harmonious interests.

“Right now I don’t do any experiments myself because of my administrative responsibilities. But I do talk to postdocs and students about their experiments and data, and I help them organize that information and also give ideas for experiments,” Kanost said. “So we sort of help each other out and make it a team effort. That’s really important for many of these larger projects.”

Similarly, performing in a symphony requires each section to build upon and play off arrangements of other sections. When in sync, something much larger is accomplished.

“I also think both help with concentration,” Kanost said. “In orchestra there are some long pieces, sometimes lasting 30 minutes or more. And in science there are times when it requires long periods of focus. That’s especially true when carrying out complex experiments and writing grant proposals. I think the stimulation that I get from both is beneficial to being able to think about each subject differently.”

But as fulfilling as the cello is, Kanost said it’s hard to envision what he would do if he weren’t in biochemistry.

“I’m glad I have science in my life because I know I’m not good enough to make a living as a musician. I’d be starving,” Kanost said and chuckled.

