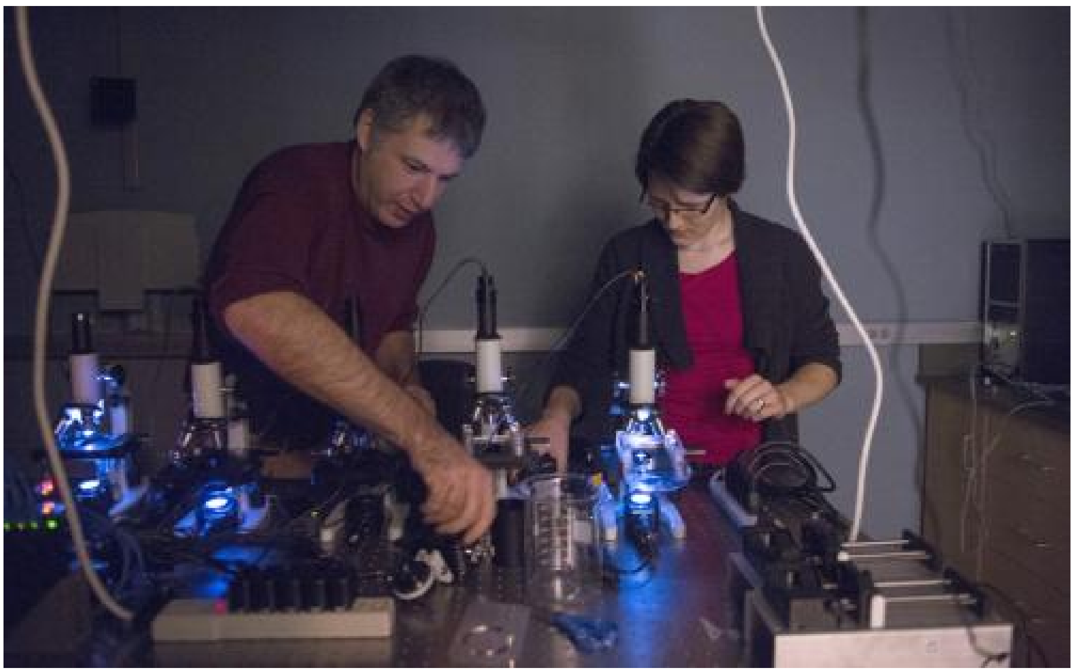
Neuroscientific studies worm their way into physics lab

December 13 2013, by Chelsea Leu



UChicago physicist David Biron and Monika Kauer, graduate student in biological sciences, make adjustments to an array of microscopes that focus on tiny worms in various stages of development. The worms, with a nervous system consisting of only 302 nerve cells, often serve as a stand-in for organisms that have more complex nervous systems. Credit: Robert Kozloff

David Biron's lab contains arrays of microscopes in darkened rooms, all focused on tiny worms in various stages of development. These worms have cameras trained on them day and night, generating tens of millions of images and hours of video footage. "Animal behavior is fascinating to me," said Biron, assistant professor in physics. "I could watch these worms for hours."

Biron studies the behavior of the roundworm *Caenorhabditis elegans* in the hopes of shedding light on the function and evolutionary origins of animal behaviors such as locomotion, feeding and sleep. He is particularly interested in the sleep-like behavior of C. elegans, and its implications for the origin of sleep in animals.

When humans sleep, our brains are rewired to forge new connections and increase brain plasticity. Though the effects of sleep are readily seen, scientists still haven't clarified how the brain regulates sleep at the molecular level. Biron hopes to contribute to an explanation using C. elegans as a simple model.

The tiny C. elegans worm contains a nervous system consisting only of 302 nerve cells, and is thus often used as a model organism in neuroscience. "It can be difficult to pinpoint causation in more complicated organisms with complex nervous systems, so we're focusing on C. elegans, which is a very simple system, in the hope that we'll be able to better understand the mechanisms of sleep," he said.

Despite C. elegans' common use in scientific research, very few researchers have studied the worm in the context of sleep. Scientists currently disagree over whether these worms "sleep" in the same way mammals do. The sleep-like behavior exhibited by C. elegans is termed "lethargus," and may only occur during its development. C. elegans sleeps only four times during its lifetime, rather than daily as most animals do, and these periods of rest are linked to the growth of a stiff covering that occurs during its development. Some scientists think these inactive periods are merely the result of the covering restricting the worm's movements, unrelated to sleep.

But the list of similarities between lethargus and sleep is growing. In a 2013 paper published in *Sleep*, Biron and his lab describe their observation that C. elegans appears to require a set amount of time in lethargus. Just as we sleep longer and more deeply when we are low on sleep, Biron and his colleagues found that if worms were prevented from entering lethargus, they would later remain dormant for a correspondingly longer period of time. "In fact, we can 'wake up' the worms during lethargus and confirm that, indeed, such a disturbance is followed by quiescence to compensate," said Nora Tramm, a graduate student in Biron's lab and a co-author of the paper.

C. elegans also contains the same molecular pathways that govern sleep in other animals. In a paper published in eLife in July, Biron and his lab described a phase called quiet wakefulness in C. elegans, in which the worms were awake, but remained relatively still. Quiet wakefulness has previously been recorded in animals such as mammals, birds and reptiles. C. elegans toggled rapidly between periods of active and quiet wakefulness, and these switches seemed to be regulated by a molecule called protein kinase A, which also encourages wakefulness and disrupts sleep in animals from flies to rats.

As of now, when and why sleep evolved remains an open question. If scientists agree that lethargus is a form of sleep, the phenomenon of sleep would have developed as early as 700 million years ago, when the ancient ancestors of C. elegans evolved. Biron and his team have high hopes, as their 2013 paper in *Sleep* is the first paper on C. elegans to be published in a journal of the sleep research community.

While Biron's lab began by focusing on sleep research, it has since grown to encompass a variety of work on C. elegans' behavior. Scientists in the lab are also researching the effects of the neurotransmitter serotonin on worm appetite and locomotion. These basic behaviors, controlled by molecules, are present in animals, including humans:

Serotonin is a chemical used in our own brains to regulate mood and appetite. "The worm is a tool to learn about our own biology," graduate student Monika Kauer said.

To answer these fundamental questions about animal behavior, Biron's lab brings together scientists from fields as disparate as physics, neuroscience and genetics. "I have seen David's lab grow from a small number of people trying to figure out how to make sense of a single phenomenon to a diverse bunch of individuals with distinct interests and abilities, all united by our fascination with the behavior of this little worm," Tramm said.

Biron is a physicist by training, and he currently teaches physics courses to students in the College. Before joining the University in 2009, Biron became interested in sleep research after reading a 2008 paper in *Nature* describing the similarities between sleep and lethargus in C. elegans. "In the end," he said, "studying the behavior of C. elegans was an emotional decision. I got caught up in the excitement of neuroscience, with all its new tools and new questions."

Provided by University of Chicago