Making out-of-this-world discoveries

Scientists illuminate the microscopic to the astronomic

UD AROUND THE World

◀ Astronomer Judi Provencal coordinated the Whole Earth Telescope's latest observing run from an international command center at Mt. Cuba Observatory in Wilmington, Del.

Putting a 'cool star' in focus

The Whole Earth Telescope (WET), a global network of observatories coordinated by the University of Delaware, finished an international relay in June. Instead of a foot race around the world, however, the observatories synchronized their lenses for four weeks of round-the-clock coverage of a cooling star.

The dying star, a white dwarf identified as WDJ1524-0030 in the constellation Ophiuchus in the southern sky, is losing its brightness as it cools, its nuclear fuel spent. As the star dims, scientists hope it will shed light on the workings of our own planet and other mysteries of the galaxy.

Like an international relay team, observers at Mt. Cuba Observatory in Greenville, Del., would focus on and photograph WDJ1524-0030 until sunrise, and then observers at McDonald Observatory in Fort Davis, Texas, and at Kitt Peak National Observatory in Tucson, Ariz., would stand watch while the star was in their sky, followed by observers in New Zealand, Australia, China, and so on, around the globe.

The thousands of photos taken by the WET team were e-mailed to the command center staffed by UD researchers at Mt. Cuba Observatory, who are now analyzing them using the fledgling science of "star quakes" known as asteroseismology, which can determine the age, temperature, and composition of a star from its oscillations and brightness.

"A white dwarf is the size of the Earth and as dense as the sun. This star pulsates or quakes as waves of energy travel through it — its outer surface sloshes from side to side like waves on the ocean," says Judi Provencal, assistant professor of physics and astronomy and director of the Delaware Asteroseismic Research Center (DARC).

"What is of interest to scientists is the shape of the pulses," Provencal notes. "From them, we can measure how the atmosphere is moving around in these pulsating stars and figure out what's going on inside them. This one is really sloshing around."

Although there are thousands of white dwarfs in our galaxy, only about 30 percent are bright enough for scientists to study using asteroseismics, according to Provencal. She notes that WDJ1524-0030 is one of only about 20 percent of the stars in the universe whose atmosphere is composed of helium versus hydrogen. The WET team hopes to find out the composition of the star's core, whether hydrogen or oxygen.

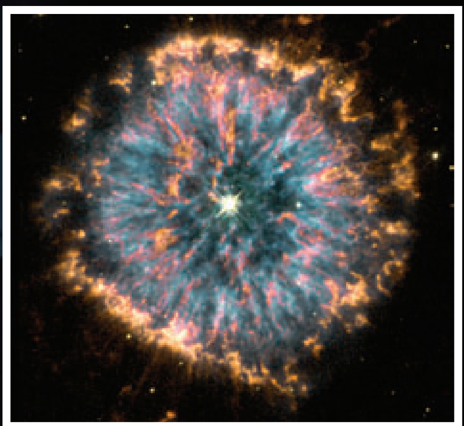
The process of discovery will take on the order of two years to stitch together all of the images, analyze the data, interpret the data with the input of the WET community, and report the results. Eventually, the findings will be applied to other stars, including the sun, and to our own planet, Provencal says.

"We don't understand the weather on Earth, the transport of energy," she says. "We don't understand convection at all. Hopefully, this field of research, which is still very new, will help every aspect of astronomy."

While the administration of the Whole Earth Telescope is supported by the Crystal Trust Foundation, the observers are not paid to observe.

"Without them, it wouldn't happen," she notes. "It's a community effort."

The latest WET run included telescopes in Austria, Chile, China, France, Germany, India, Italy, Lithuania, New Zealand, Poland, Russian Federation, South Africa, South Korea, Spain, Taiwan, and the United States, including Arizona, California, Delaware, Florida, and Texas.



▲ ***The bright star inside this nebula (gas cloud) is a young white dwarf. Courtesy of Space Telescope Institute/NASA and the Hubble Heritage Team.***

◀ *Peak Terskol Observatory in the Russian Federation was among the participants from 16 countries in the Whole Earth Telescope's latest observing run.*

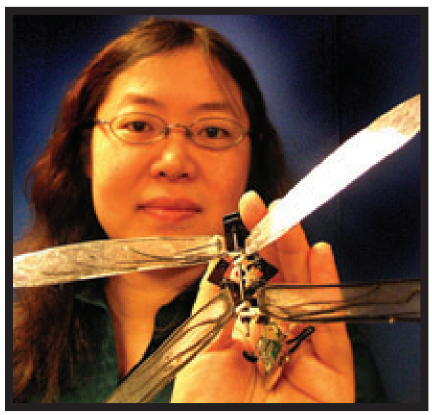
Robots take flying lessons from animals

Xinyan Deng is on a quest to build a better flying robot. Mechanical dragonflies to robotic boxfish inhabit her lab in the Department of Mechanical Engineering.

A study in the April 10 issue of *Science,* co-authored by Deng and graduate student Bo Cheng in collaboration with biology professor Tyson Hedrick at the University of North Carolina, sheds new light on how animals fly.

For Deng, assistant professor and director of UD's Bio-Robots Laboratory, the research provides the foundation for the next generation of flying robots — tiny flapping devices with a variety of potential military and civilian applications ranging from surveillance and security to search-and-rescue operations.

Previously, in research supported by her 2006 National Science Foundation Faculty Early Career Development Award, Deng developed a mathematical model of saccade flight in fruit flies. Saccade flight comprises a series of straight flight paths punctuated by rapid 90-degree turns. From that study, she found that flapping fliers benefit from a passive "braking system" now known as flapping counter-torque, or FCT.



Xinyan Deng with robotic insect.

Basically, Deng explains, when a fruit fly turns, the outside wing moves faster during the down-stroke while the inside wing moves faster during the up-stroke. This asymmetry produces the torque that slows body rotation and straightens out the ensuing flight path.

Hedrick had learned of Deng's work with fruit flies and proposed a collaborative study when they met at the Fourth International Symposium on Adaptive Motion of Animals and Machines last year.

Using high-speed video cameras, the team observed that flying animals of all sizes, from fruit flies to large birds, seem to benefit from FCT and demonstrate a similar ability to turn in flight and then straighten out to fly on a new course.

The researchers discovered that animals with similar morphology exhibit similar turning dynamics in terms of wingbeats regardless of body size. They also found that the faster the wings beat, the better the animal's maneuverability and stability. These two properties are usually antagonistic in engineering systems.

As one news story about the research announced: "Birds do it, and now we know how."

Mysterious nature of glass explained in a 'twinkle'

Archaeological evidence suggests that glass was first made in the Middle East sometime around 3000 B.C. Today, some 5,000 years later, scientists are still perplexed about how glassy materials make the transition from molten to solid state. Richard Wool, professor of chemical engineering, thinks he has the answer.

In a paper published in November in the *Journal of Polymer Science Part B: Polymer Physics*, Wool documents a new conceptual approach — the Twinkling Fractal Theory — to understanding the nature and structure of the glass transition. The theory provides a quantitative way of describing a phenomenon that previously had been explained strictly from an empirical perspective.

As water freezes, the molecules settle into a neat and orderly crystal pattern. As glass turns from a molten liquid to a solid, its molecules slow down, but they never completely stop. Even after hardening, glass mysteriously retains the molecular disorder of a liquid.

Another difference between glass and more conventional materials is that its transition from liquid to solid does not occur at a standard temperature, like that of water to ice, but instead is rate-dependent: the more rapid the cooling, the higher the glass transition temperature.

Wool discovered that as molten glass cools and transitions to a solid, the atoms form clusters of crystals in fractal shapes. As the molecules jump from liquid to solid and back, the energy at which they vibrate changes, and they "twinkle," according to Wool.

"At the glass transition temperature, these fractals appear to twinkle in a specific frequency spectrum," he says. "The twinkling frequencies determine the kinetics of the glass transition temperature and the dynamics of the glassy state."

Even after molten glass cools and hardens, its molecules never completely stop moving.

Wool says the Twinkling Fractal Theory has the potential to shed light on the behavior of all kinds of glassy materials, including polymers, metals, and ceramics, and may contribute to a better understanding of such phenomena as fracture and physical aging of materials, as well as new insights into nanomaterials.

Internet2 deploying UD technology

Martin Swany, assistant professor of computer and information sciences, and his students are helping to develop the next generation of the Internet.

Phoebus is the name of the Greek god of light. It's also the name of a bright, new technology developed by Martin Swany, assistant professor of computer and information sciences, that has been selected for deployment by Internet2, the research and development consortium that is inventing and testing the technologies that will create tomorrow's Internet.

Led by over 200 U.S. universities, working in partnership with industry, government, and international partners, Internet2 operates an advanced network that connects more than 50,000 research and education institutions in the United States and more than 80 international research networks. UD has been a charter member of the consortium for nearly a decade.

The Phoebus platform is being deployed by Internet2 as an experimental prototype with the goal of significantly improving network performance for long-distance, high-capacity data transfer that today is very difficult to achieve using traditional Internet Protocol (IP) technology. Such a tool could play a critical role in supporting major scientific projects that require high-performance networks to connect researchers around the globe.

Phoebus works by enabling Internet2 to automatically switch large data flows from its IP network, which is shared among all the Internet2 users, onto dedicated circuits or paths. By transparently moving high-demand applications onto these dedicated paths, Phoebus improves network performance because the application can benefit from the more precise service qualities of circuit networking, while placing much less strain on the shared IP infrastructure.

"The Internet2 network provides our members with a proving ground for new technology and services like Phoebus," says Rick Summerhill, chief technology officer for Internet2. "We are excited about the potential of Phoebus to enable our members to experiment with and better leverage the high performance capabilities of the Internet2 hybrid optical and IP network environment."

Swany says UD students have been critical in the development of Phoebus, and that research on the technology is continuing.

Associate professor Joseph Fox and doctoral student Melissa L. Blackman have devised a fast chemical reaction for tagging biomolecules.

Fast chemical reaction may speed drug discovery

Chemist Joseph Fox and his research group have developed a super-fast chemical reaction process for labeling biomolecules. The patent-pending technique ultimately may speed the discovery of new drugs and biomaterials.

The research, which also involved doctoral student Melissa L. Blackman and former post-doctoral researcher Maksim Royzen, was published in the *Journal of the American Chemical Society* in September and highlighted in *Chemical and Engineering News* in October.

The latter publication quoted chemical biologist Carolyn R. Bertozzi of the University of California Berkeley, who said the kinetics of the UD reaction are "perhaps the fastest reported for any bioorthogonal ligation to date."

Bioorthogonal reactions are tools that allow for the tagging and visualization of biomolecules, a field that is growing as researchers seek to develop new drugs and novel biomaterials such as artificial organs and tissues.

The 2008 Nobel Prize for chemistry was awarded to scientists who discovered the green fluorescent protein, which allows scientists to tag and monitor individual living cells and their proteins. The tagged particles appear bright green under blue and ultraviolet light.

In technical terms, the labeling method developed by Fox and his group is defined as an inverse-electron-demand Diels-Alder reaction. In it, an electron-rich cyclooctene dienophile reacts with an electron-poor diene, tetrazine.

In addition to working rapidly, the chemical reaction process works in water and can withstand interference from the many complex reactions that occur within biological systems.

Currently, Fox and his team are collaborating with other groups to use the UD technique to put radioactive labels on proteins. Such a "tagged" protein could be designed to bind to a cancer cell versus a normal cell, for example, he says, providing high-resolution diagnostic imaging.

Fox says his group came upon the discovery while working in a completely different area.

"Sometimes you have to leave yourself open to let the science tell you where to go," he notes.

He and his research team are working to perfect the chemistry of the reaction to make it as useful as possible. Since the original paper was published, the second generation of the chemical reaction already has been developed.

Avian flu research a national partnership

The University of Delaware's expert staff and state-of-the-art avian influenza facilities play a critical role in the health of the poultry industry, a major food resource and economic driver on the Delmarva Peninsula.

Yet UD's avian influenza diagnostics and emergency response programs have impacts far beyond the region.

UD is a member of a national partnership of 18 leading research institutions called the Avian Influenza Coordinated Agricultural Project (AICAP), which is working to prevent and control avian influenza.

Originally established in 2005, the project received a $5-million renewal grant from the U.S. Department of Agriculture's (USDA) Cooperative State Research, Education and Extension Service last year.

In addition to UD, and the University of Maryland College Park, where the grant is administered, participating institutions include Virginia Tech, Auburn University, University of California-Davis, University of Georgia, USDA-ARS-Southeast Poultry Research Laboratory, Ohio State University, Oregon State University, Texas A&M University, and Western University Health Sciences.

"The AICAP is unique and successful because it brings together top scientists to broadly address avian influenza challenges facing animal agriculture," says Jack Gelb, chairperson of the Department of Animal and Food Sciences, professor of avian virology, and director of UD's Avian Biosciences Center. "It basically applies the land-grant agricultural philosophy to an important disease with clear poultry health consequences and potential human health implications."

Doctoral student Michele Maughan is investigating the immune response of different poultry species to avian influenza.

Among its accomplishments since it was founded in 2005, AICAP has:

- Assembled the first continent-wide network to study the ecological and biological characteristics of avian flu viruses isolated from wild birds;
- Shown that quail can change and expand the host range of avian flu viruses, and found that quail respiratory and intestinal tracts have human-like sialic acid receptors that could partially explain the emergence of avian flu strains with the capacity to infect humans;
- Developed a comprehensive training program for producers and veterinarians in 33 states and in Canada and Brazil;
- Developed a test for rapid diagnosis of avian flu in birds; and
- Developed promising vaccines for mass immunization of birds.

Avian influenza research and outreach activities at UD are supported by AICAP, as well as state and other federal funds. Projects include surveillance programs in commercial poultry, backyard flocks, and wild birds; development of rapid diagnostic tests; emergency poultry depopulation research; in-house composting for responding to catastrophic poultry losses; efficacy of disinfectants and common chemical compounds on avian influenza virus; viral pathogenesis and vaccine evaluations; and regional, national, and international technical assistance programs. Internationally, UD researchers have assisted scientists from Turkey, India, Bulgaria, and Romania.

UD's avian influenza diagnostic team received special recognition at the 2008 Delmarva Poultry Industry (DPI) awards ceremony. The team routinely performs surveillance for avian influenza among commercial broiler chickens and backyard flocks and tests diseased flocks.

"One of this group's watershed moments was when the workloads peaked at an all-time high in 2004, the year Delmarva's chicken industry encountered and successfully controlled low-pathogen avian influenza," said Bill Satterfield, DPI executive director at the event. "These individuals were the backbone of poultry diagnostic services on Delmarva, with the help of other colleagues in the University of Delaware and in the region. Our industry owes a great deal to this team for its talents, willingness to pitch in when necessary, and hard work over the years."

For more information about UD's poultry health system and the Avian Biosciences Center, visit **ag.udel.edu/abc/**.