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Science Issues—Is There a Gay Gene?

The search for a biological cause of homosexuality has been politically problematic since the early 1990s, when the first significant studies of sexual orientation began to be published. The best known of these are the 1991 study by researcher Simon LeVay, which found a significant size difference between a certain portion of the hypothalamus in a group of gay men versus a group of straight men, and a 1993 project at the National Institutes of Health led by Dean Hamer, which found a similar marker among pairs of gay brothers in one region of the X chromosome, Xq28. A study begun in 2004 and led by Alan R. Sanders at the Evanston Northwestern Healthcare Research Institute further probed a genetic link to homosexuality, but has not yielded conclusive results.

Research into this topic is necessarily fraught with political and social consequences. Some queer activists welcome this link between biology and sexual orientation as a way to silence the antigay sentiment that homosexuality is an immoral lifestyle choice. However, establishing a biological cause of homosexuality also potentially makes it a condition that can be "cured" or even eradicated. Additionally, many studies in this area compare groups of "gay" men to groups of "straight" men, a process that ignores the fluidity of sexual identity. One must ask, what constitutes "being gay"? Where in this scheme do bisexuality and pansexuality fall? It bears noting, too, that most studies are markedly focused on the biology of gay men—perhaps the most historically visible subsection of the queer community, but nonetheless only a portion of the range of sexual orientations and gender identities existent within it.

For all the potentially phobic ends to which this research might be used, however, studies of the biology of sexual orientation may also demystify the subject in ways that combat the discrimination with which our current society often treats nonheterosexual persons. This research, then, must responsibly understand the social and political consequences of locating a biological cause for homosexuality. The pursuit of knowledge is, in this case, inextricable from politics; to deny this would be irresponsible.

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Please submit letters to the editor to catalyst.au@gmail.com.

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Mission Statement:

A catalyst, as defined by scientists, facilitates chemical reactions by bringing together substances that might not interact in its absence. Similarly, *Catalyst* is one place where all the sciences come together to relay exciting scientific developments happening at AU in the AU community and beyond.

Catalyst is a semiannual magazine created to promote discourse and keep us up to date about how science at AU affects and inspires us all. Our mission is to: serve students and faculty in the sciences as a means to inspire, inform, and promote discourse; share news and accomplishments of students and faculty; inform students of timely and valuable opportunities; raise the profile of the sciences at AU; and expose students outside of CAS to exciting science classes.

Our success will be measured by how useful and informative you find this publication. So we want to hear from you!

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"The Hot Spot for Science Education"

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ON THE COVER Inspired by the film *Edward Scissorhands*, the cover features AU alum Mark Meyer, BS math and statistics '08. Costume and makeup by Barbara Tucker Parker, CAS, Department of Performing Arts costume designer. Photo by Jeff Watts

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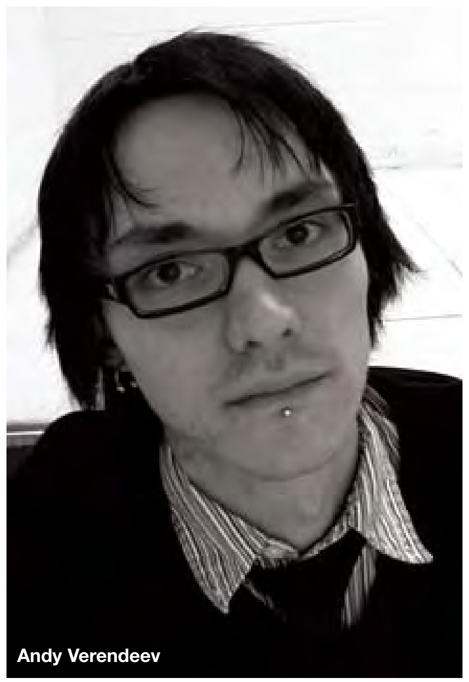
TABLE OF CONTENTS

Photos by Kerry Chu, Courtesy of National Museum of Natural History, Smithsonian Institution

A PEEK INTO PSYCHOPHARMACOLOGY: RATS ON DRUGS

By Nadia Ramlagan, biochemistry '08

Photo by Andy Verendeev



Andy Verendeev

Andy Verendeev didn't end up at American University the way most students do. He was born in Russia and at age 18 moved to Istanbul, Turkey, a place where he knew no one and could barely speak the language. There, he found a job and enrolled in a Turkish language school. "It was an adventure; it was great. By the end of the first year I decided I wanted to stay in Istanbul and go to college," Verendeev reflects.

While at Bogazici University, one of Turkey's leading research universities, his interest in experimental psychology flourished when he began working in two labs at the end of his first undergraduate year, studying animal models of depression and sexual conditioning in quail. "The more I read, the more I became interested in biological psychology," Verendeev says. Serendipitously, he mentioned a desire to study in America to a professor who happened to be a friend of Anthony Riley, the chair of the Department of Psychology and director of the psychopharmacology lab at AU. Temporarily suspending his undergraduate studies at Bogazici, Verendeev packed his bags and headed for the States.

"As an undergraduate in Turkey, he took time off from school to volunteer in my laboratory for three straight summers—at his own expense. During his visits, he was active in research and coauthored several journal papers and presentations at national conferences. He was constantly engaged [in his work] and interested," says Riley. "Simply put, he is a smart fellow. He reads voraciously and simply loves to talk about science. There are few sure bets in our work; he is one of them."

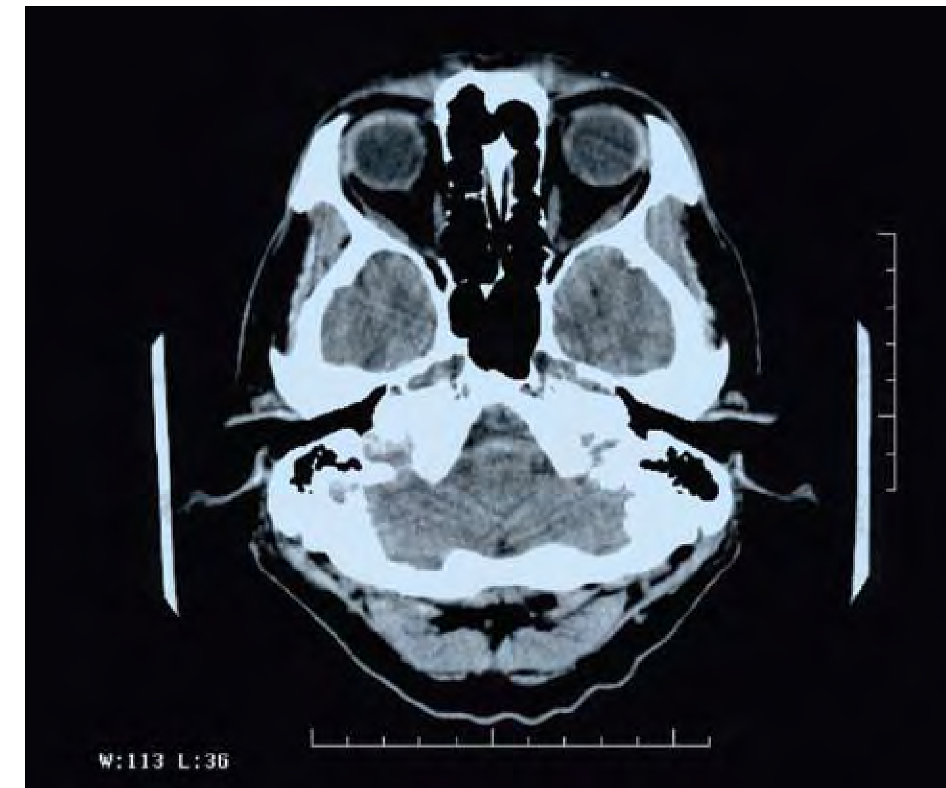
Verendeev is currently pursuing his PhD in behavioral neuroscience at American University. Supported by a grant from the Andrew W. Mellon Foundation, his research involves examining factors that might be related to the susceptibility to use and abuse drugs. In particular, he is focused on the relationship between the aversive and rewarding effects of drugs. "He is looking at these factors and how they might interact to impact initial drug taking, and how they might vary with a host of conditions to increase the likelihood of drug use," says Riley. Current statistics show that drug abuse and drug-related mortality continue at alarmingly high levels in the United States. Advancing scientific understanding of drug use and abuse at the neurobiological level is an important step toward greater capacity to reduce negative consequences on the individual and society.

Verendeev employs reward and aversion in his research. Originating in the 1920s with Ivan Pavlov's experiments with dogs, reward and aversion are components of what is broadly known as classical conditioning. Conditioning in animals occurs when a neutral stimulus (in Pavlov's case a bell, which has no inherent meaning to a dog) is paired closely in time with a meaningful stimulus, such as food. The term "reward" describes a stimulus that has a positive meaning, while "aversion" describes a stimulus with negative meaning. The animal learns to associate the neutral stimulus with the meaningful stimulus and will eventually display a certain behavior corresponding to the neutral stimulus. The dogs learned to associate the bell with food and eventually began to salivate immediately after hearing the bell. When the meaningful stimulus is a complex compound with multifarious effects on the brain, such as a drug, the lines between reward and aversion become muddled.

Working with morphine and rats, Verendeev combined two specific methods: conditioned taste aversion (CTA) and conditioned placed preference (CPP). These allowed him to measure specific motivational effects of drugs; CPP is a measure of drug reward and CTA is a measure of drug aversion. Over several trials, he paired morphine with saccharin (an artificial sweetener) and injected rats with the drug. Following conditioning, rats learned to avoid saccharin because it became associated with the aversive effects of morphine. "It's the discomfort of the novelty of the drug state and some aversive property of the drug that rats don't like," explains Verendeev. Additionally, the same rats injected with morphine also displayed a continued preference for an experimental chamber that was paired with the drug, as measured by CPP. "People abuse drugs because the reward outweighs the aversion. My data show that rewarding and aversive effects occur at the same time," he said.

In the second phase of the experiment, Verendeev attempted to extinguish the newly acquired CTA and CPP in the rats.

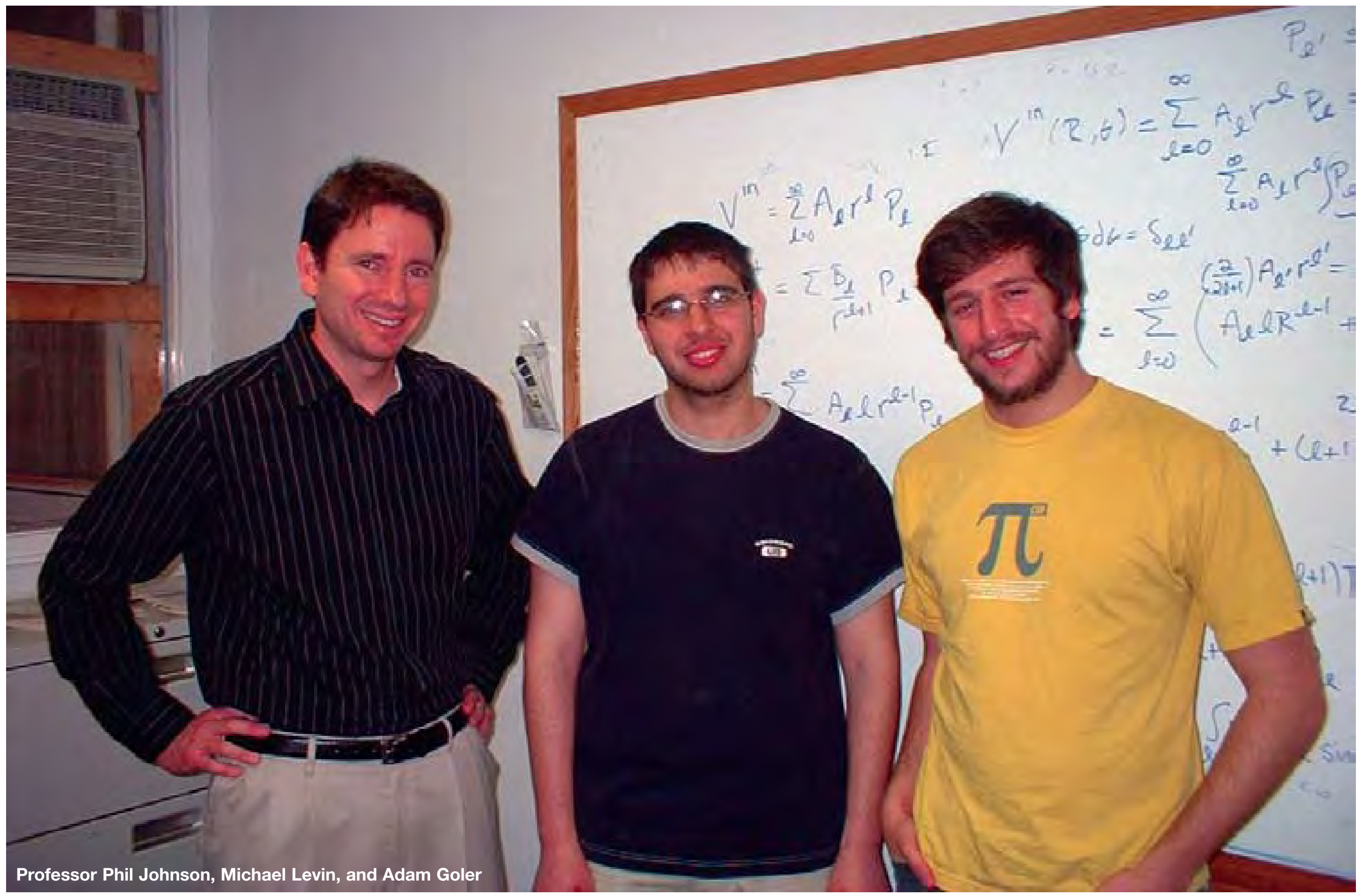
Conditioned taste aversion and conditioned placed preference are common experimental procedures used in behavioral psychopharmacology research. Placing animals injected with a rewarding drug in a chamber with distinctive environmental cues leads animals to develop an association between the rewarding effect of the drug and the specific environment in which the effect is experienced. In contrast, the CTA procedure conditions animals to learn the association between a novel taste and aversive effects of an otherwise rewarding drug, and learn to avoid the taste in the future. Taste aversions are also observed in humans, for example when taste is accompanied by gastrointestinal illness.



Verendeev's research highlights the complexities of the correlation between reward and aversion. "The data suggest that there might be a common brain mechanism mediating both aversive and rewarding properties of the drug," Verendeev concludes.

After neuroscience, Verendeev's other scientific interest is evolution, particularly the mechanisms of evolution, a topic he also hopes to do research in someday. As for returning to his birthplace, he says, "I haven't been to Russia in a long time. I have no plans to go back. I love what I am doing here."

Photo by Shikole Struber



Professor Phil Johnson, Michael Levin, and Adam Goler

CRACKING THE CODE

Senior physics students Adam Goler and Michael Levin team up with Professor Phil Johnson to research superconducting qubits

By Shikole Struber, political science and journalism '10

Since the ancient Egyptians, people have been trying to decipher codes. But some modern encryptions are so complex that even the strongest computers can't crack them. Two American University seniors, Adam Goler and Michael Levin, along with Professor Phil Johnson, have been researching superconducting qubits, the basic building blocks necessary for a quantum computer that could decipher these codes with ease.

Goler and Levin, in partnership with Johnson, have been studying the physics of the superconducting qubit to make a prototype. "Adam, Michael, and I have built a computer simulation of a promising general type of superconducting qubit," said Johnson, who teaches in the College of Arts and Sciences' Department of Physics. The device would consist of tiny loops of wire cooled to within a few thousandths of a degree above absolute zero. The electric current in these tiny loops would then oscillate at distinct frequencies. The two oscillations would be used as zero and one values, the binary language of all computers. Unfortunately, there have been additional, unexpected oscillation frequencies and these appear to be seriously degrading the quality of the qubit, according to Johnson. No one is sure where these extra oscillation frequencies are coming from and experimentalists are trying hard to get rid of them, mostly by trial-and-error modifications of their prototypes.

Goler, Levin, and Johnson are using their simulation to predict the qubit's behavior over a broad range of conditions and design parameters. "We hope that our work will help experimentalists focus on the most promising qubit designs rather than wasting a lot of time following an inefficient trial-and-error approach," Johnson said.

A quantum computer is a machine that would exploit the deepest laws of quantum mechanics and operate in a way fundamentally different from present-day computers. For certain tasks, a quantum computer would be capable of solving problems that even the most powerful supercomputers find essentially insoluble. Its most important application will likely be to provide a tool for deeper exploration of the laws of quantum physics themselves.

A quantum computer would operate by the same quantum mechanical laws that govern atoms and molecules. For this reason it would easily and efficiently be able to simulate the behavior of physical systems of molecules being put together. Currently, new prescription drugs are developed by laboratory trial and error. However, there are an amazing number of ways molecules can be assembled, making this method inefficient. Johnson explained that one could spend years and discover only a fraction of the possibilities. A quantum computer could be used to accurately model types of nanotechnologies (devices so small that they, too, operate according to the laws of quantum mechanics, but which are still far too complex for ordinary computers to simulate). This research could potentially revolutionize medicine.

Of the process that the team used in its study, Goler says, "[First] we study the mathematical representations of the superconducting qubit, and second, simulate the properties of the qubit with [the computer program] Mathematica in order to examine 'tunnel splittings' that appear."

If a functioning quantum computer could be built, there would be serious national security and economic effects. Credit card information, as well as military intelligence, could be hacked. Johnson also explained that, conversely, these computers would be able to send information that would be indecipherable. This could make the government's national security efforts even more difficult.

To conduct this research, Goler and Levin have won Dean's Undergraduate Summer Research Awards from AU's College of Arts and Sciences. Johnson has funding from the American University Faculty Research Award, and beginning this January he will also receive external funding from the Cottrell College Science Award, granted by the Research Corporation with funding for the next two years.

GRADUATE BIOLOGY STUDENTS STUDY EVOLUTIONARY DEVELOPMENTS IN TINY FRESHWATER CRUSTACEANS

By Andrew Frank, biology and environmental studies '11

American University students Karen Kavanaugh and Kerry Chu both have their eyes on tiny shrimp-like creatures from all around the Washington, D.C., area. However, you wouldn't want to chow down on these guys at any New Year's party.

Kavanaugh and Chu both work in Professor Daniel Fong's laboratory as part of their graduate independent studies. They are conducting research on the pinhead-sized organisms better known as amphipods, in the families Gammaridae and Crangonyctidae. These are minuscule crustaceans dwelling in streams, rivers, lakes, and swamp-like seeps around the world. Most of us are probably more familiar with their terrestrial and marine relatives, the sand flea and marine shrimp. What fascinates these two students isn't the incredible range of these tiny crustaceans and their relatives; it's the unique living space in which they thrive and the evolutionary changes that make amphipods prime model organisms for pressures on the surrounding environment.

Kavanaugh began her studies as a biologist at Bucknell University, graduating in 2004 with a BA in animal behavior, a subject which has fascinated her for much of her childhood and adult life. When Kavanaugh decided to come to AU to continue her studies toward a higher degree, she began as a researcher in Professor Catherine Schaeff's lab, working with fluctuating asymmetry in marine mammals. Here, Kavanaugh investigated the relationship between the symmetry of the bodies of marine mammals and their health as a population (evidently dolphins think it's really sexy to be the same on the right as you are on the left!). Kavanaugh's work in Schaeff's laboratory soon led her to Fong's lab and her current studies of population genetics. As a continuation of her studies, Kavanaugh has studied populations of amphipods in the Maryland, Virginia, and Washington, D.C., area. She works with amphipods in one of the most difficult environments in which to study these tiny creatures—a seep—and studies their DNA sequences to help understand evolutionary mechanisms that are taking place.

Seeps are one of the prime environments in which amphipods tend to dwell. A seep consists of water, or sometimes petroleum, slowly leaking out of the ground, often from caves or underground sources. Amphipods take advantage of the water-soaked environment to eat their favorite snack, microscopic bacteria that grow on wet leaves. Because amphipods are very temperature-sensitive, Kavanaugh must work during the spring to capture specimens from these seeps. When the time is ripe for collection, Kavanaugh heads to one of nine known seeps in the greater Washington, D.C., area. Once there, she must trudge through thick mud and dead leaves to snag just a few creatures to bring to the lab.

Back at the lab, Kavanaugh begins to prepare her samples to be sent out to have their DNA code analyzed. Currently collecting and preparing these samples, Kavanaugh hopes that once the DNA analysis returns, she will be able to clearly identify evolutionary patterns which indicate mechanisms at work. Analysis employs complex statistical computations that allow her to see the evolution of the seep amphipods in the past, and where it might be headed in the future.

In the future, Kavanaugh will apply her work to understanding invasive species' effect on the environment around Washington, D.C., including research in the George Washington Memorial Parkway area.

Working alongside Kavanaugh in the lab is Kerry Chu. Chu graduated from AU with a BS in biology and has decided to continue her work toward a master's, working with Professors Christopher Tudge, Victoria Connaughton, and Fong in his lab on morphological features of amphipods. Like Kavanaugh, Chu is looking at the evolutionary mechanisms of these tiny crustaceans. Her objective is to compare the morphological features of different amphipod populations, not their DNA, using a high-powered microscope and camera known as a scanning electron microscope (or SEM), which produces incredibly detailed images. Chu got her start working with amphipods back in her undergraduate years while doing an independent study with Tudge, who introduced her to the science of crustacean biology. "I became fascinated with amphipods after I saw them because initially they looked like the little dried, preserved shrimp that were sold in the Asian supermarkets, but I soon found out they were not shrimp," says Chu about some of her first experiences with the tiny creatures. During this study, she learned the complex structures of the amphipods and how to photograph them using the SEM.

Photo by Bryan Adams

Karen Kavanaugh

Now as a graduate student, Chu uses these same techniques to examine amphipods from habitats like springs, caves, and seeps and compares differences in their appearance. "The goal of this experiment that I'm doing now is to find morphological differences between cave and surface populations/species of amphipods that have been isolated for different lengths of time in caves, and between cave species that occupy different habitats underground." Not surprisingly, amphipods in the cave look strikingly different from those above ground, with adaptations that eliminate the need for eyes in an environment of total darkness. To take a good look at amphipods, Chu first takes samples of the amphipods collected from various environments in the field, then preps them for photography by dissecting and completely dehydrating the specimens. Once a special coat is applied to the amphipod, it's ready to be observed and photographed under the SEM. This process is very time consuming and difficult because the amphipod body parts being observed are extremely small. "These body- and mouth-parts are 1 millimeter or less in length and are very brittle, so a mistake will result in a do over of the entire process," she explains. It's also difficult to get access to the high-powered SEM at the National Museum of Natural History, Smithsonian Institution, where scientists from around the United States and the world use the microscope to observe the minutest details of objects. Once Chu finishes collecting, preparing, and photographing the amphipods, which she hopes to accomplish by the next fall semester, she'll be able to clearly observe the fascinating evolutionary differences that occurred in the different environments in which the amphipods dwell.

Photo by Kerry Chu. Courtesy of National Museum of Natural History, Smithsonian Institution

EREK ALPER AND THE FRANKLIN INSTITUTE

By Kristen Boghosian, journalism '10

You can tell when people are truly passionate about physics. They use terms such as "vacillating" in regular conversation and get a twinkle in their eye when they do. Erek Alper is one of these people, and last summer he had the opportunity to help pass on his passion to others.

But Alper wasn't always so passionate about the subject. In fact, he dreaded going to high school physics. Luckily, a friend at American University recommended he take an astronomy course at AU. Taking physics planted in Alper a love for science that would grow in the coming years.

A desire to study astronomy was inspired by a visit to the workplace of a family friend, Craig Foltz. Foltz was an astronomer at the University of Arizona at Tucson, and he showed the Alper family the telescope he used in his research. "Everybody is impressed when they visit an observatory, but I remember that Erek just lit up with his characteristic big, broad smile," Foltz recounted. Alper vividly remembered his introduction to astronomy. "He seemed to love it so much," Alper said of Foltz. "It just struck a chord with me." Astronomy became his hobby, and a job in the field became his dream.

It was this dream that pushed him toward the Franklin Institute, a science museum in Philadelphia, Pennsylvania, with the intention of educating the public about science and technology. As an intern there, Alper had big plans: he wanted to work with the Franklin Institute's chief astronomer, Derrick Pitts. At his interview, the two discussed plans to enhance visitors' experiences of the institute's astronomy exhibits. Alper hoped to put his love of astronomy and knowledge of audio-visual skills to use by linking a television screen to one of the institute's telescopes, giving viewers a big-screen view of the sky. Unfortunately, this dream never fully came to fruition.

Instead, Alper became an expert in many of the institute's user-friendly displays and exhibits, giving talks and demonstrations on their subjects. His favorite work was in the observatory, where he spent most of his time. This room housed five eight-inch reflecting telescopes, along with a 10-inch Zeiss refracting telescope. A Zeiss telescope is different from most telescopes in that it uses a complex system that shifts weights to adjust to different orientations. It was recently redone to be computer operated and now requires little hands-on adjustment.

Alper introduced observers to the telescopes and discussed what they saw. Because visitors came during the day, he would attach different filters to the Zeiss refracting telescope, allowing people to use the telescope to look at the sun. With the use of a hydrogen-alpha filter, they could watch the sun's surface undulating, and another filter allowed them to witness solar flares.

When Alper wasn't sharing his knowledge of astronomy with the crowd in the observatory, he furthered his knowledge of the other exhibits. The heart room, for example, featured a giant walk-through heart along with interactive displays that aid in understanding the organ's scientific processes. Here, Alper spoke to visitors about the heart's functions and dysfunctions and the medical technologies related to the heart. He also showed various plasticine animal hearts, allowing people to compare them.

Alper always did what he could to make the less interactive rooms more exciting. To involve kids in an exhibit on ancient Egyptian medicine, he assigned them diseases and helped them "cure" each other. In the Paper Booth, he joined the groups to make paper from recycled materials, and he taught them about the history of paper. Other exhibits needed less work. In the Sports Room, for example, there is a mannequin with equipment from over 50 sports.

Alper found the Brainteasers and Newton's Corner rooms great fun. In the former, exhibit workers had to learn how to solve the puzzles before working the exhibit. Once they did, they helped nudge participants in the right direction. According to Alper, this was a great opportunity to get to know the tourists. Newton's Corner, devoted to the basic principles of physics, featured levers, pulleys, tensions, and weights. These displayed angular momentum, perpetual motion, conservation of energy, and similar concepts, which Alper would explain to eager audiences. Although he was unable to enhance the astronomy exhibits as hoped, he still loved the experience.

Since his work at the Franklin Institute, Alper has turned away from astronomy as a career. "What purpose is there in studying other planets if we won't have this one much longer?" he asked. His change in direction is perhaps understandable, considering his family background. Alper's father worked with the Environmental Protection Agency, so Alper grew up in a household that emphasized recycling and conservation. He now hopes to work with alternative energy. While he still loves astronomy as a hobby, he wishes to make more of a contribution to his own planet.

Last summer, helping the planet was the subject of Alper's internship. He worked at Drexel University, researching alternative light energy. The program, called a Research Experience for Undergraduates, was hosted by the National Science Foundation. Alper joined a team of students searching to develop a marketable energy-efficient light bulb—bringing us one step closer to eliminating what he calls "those damn fossil fuels."


Erek Alper

Photo by Kristen Boghosian

Walid Sharabati

Photo by Jeff Watts

A SMALL WORLD, GETTING SMALLER

Math and statistics instructor Walid Sharabati researches the degrees of separation in online social networks

By Esther Song, journalism and international studies '11

There exists a theory that any person on the planet can be connected to any other person through a chain of no more than five acquaintances. In other words, there is a maximum of six degrees of separation between any two people on Earth.

The theory has recently piqued the interests of the public. In pop culture, the experiment to prove this theory as valid has been popularized through a movie, a screenplay, a short-lived ABC television series, groups on Facebook.com, and celebrity endorsement.

Closer to home, American University's Walid Sharabati, a resident statistics and mathematics instructor, has been conducting some research on his own, related to the six degrees experiment—with Internet networking sites.

To conduct his research, Sharabati says he requires three things: a fast computer, computations and algorithms, and capable software. To test the validity of the Six Degrees Theory, Sharabati simulated the global network by forming his own group using LiveJournal.com to create a network based on people's taste in music, but "with certain rules," he said.

To join the network, an individual must have at least one friend in the network with whom he or she shares a similar taste in music and that individual's friend must have a friend, and so on and so forth. "The most difficult part is gathering data," Sharabati said.

After creating the simulation, he then ran it through a network software program that calculated statistics, including the popularity or density of the network, any key players in the network, and most importantly, the average network distance between each individual. "I ran the simulation 1,000 times and the results were very close—seven degrees," said Sharabati. He went on to say that if he had done a reiteration another 1,000 times, the results would probably be even closer to six degrees.

The six degrees theory is not a new phenomenon, however. Theories of separation took hold in the 1960s and 1970s, "when the network diameter was 11 to 12 degrees," Sharabati said. The network diameter is the measure of separation between individuals. Since then, technological advancements, particularly the Internet, have reduced the distance between individuals or actors down to six.

Sharabati predicts that in the future, the diameter could become as low as four or five, but to go any lower would be extremely difficult. "A network diameter of one or two would mean that everybody in the world would know everybody," he said.

Social networks such as Facebook.com, Myspace.com, and Livejournal.com have contributed significantly. "It's a hot topic," says Sharabati, "and it interests me greatly."

Networking sites such as Facebook have spawned popular groups as amateur attempts to prove the six degrees experiment. Even actor Kevin Bacon has launched a Web site dedicated solely to proving this idea. The problem with these groups, says Sharabati, is that the data they collect are unscientific. The samples themselves are biased, which makes a poor foundation for research. "Many people [in the world] don't have Facebook," said Sharabati. This makes for a smaller community. If tested and run through the simulator, the data would yield a suspiciously small four to five degrees of network diameter.

According to Sharabati, all of the gathered research can be applied in two ways. The first is analytical and is used solely for theoretical purposes in support for the six degrees theory. The second is used for more real-world applications, including epidemiology and computer virus control.

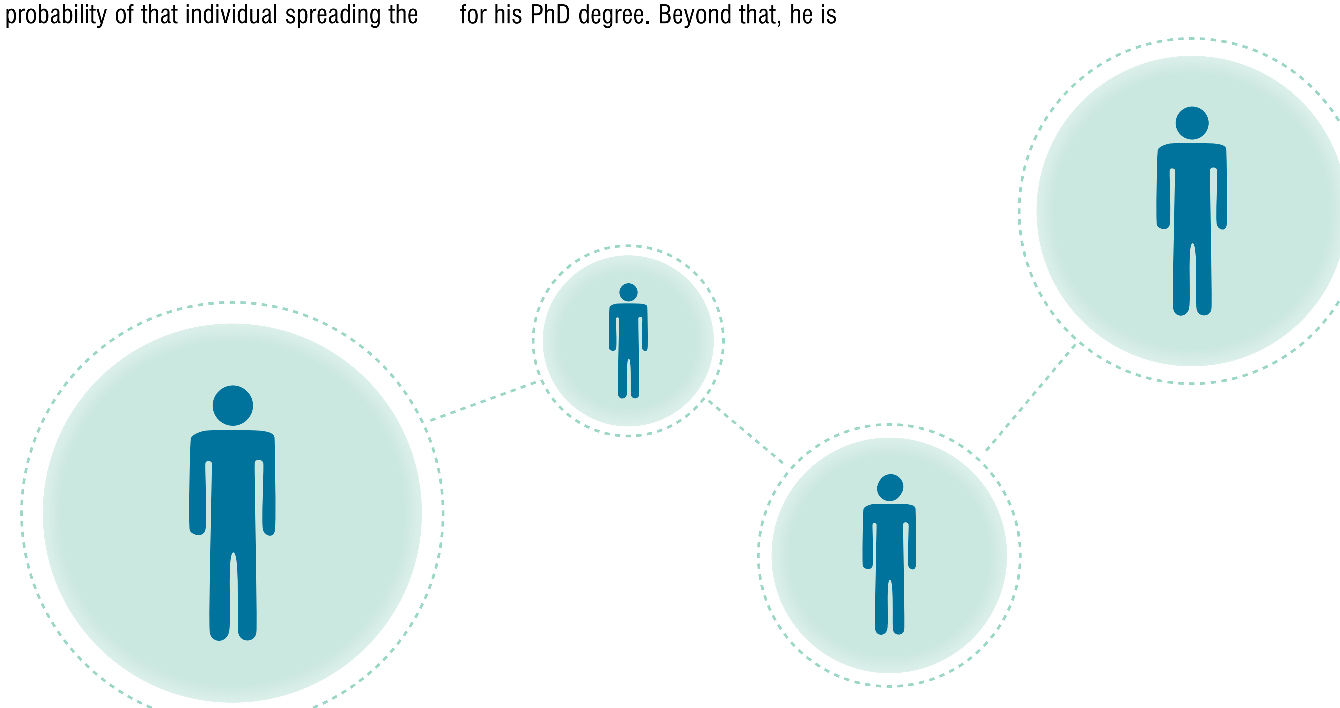
With network analysis software programs such as Pagek (which means "spider" in Slovenian), Aura, and UCINET, researchers can obtain the key players in certain networks. More importantly, the programs also measure the centrality or popularity of a certain individual by the number of actors that individual is associated with.

This has proven helpful for those finding ways to contain diseases. By networking people with the disease and those who are prone to it, the software can identify the most important actors—those who have a high level of centrality—and those who are at low risk—a low level of centrality. If an actor with a high level of centrality catches a disease, the probability of that individual spreading the disease is very high. With this information, quarantine can quickly be established.

In the computer world, a similar technique and application is used. As with individuals prone to disease, the software identifies those computers with a high centrality and those with lower popularity. Hackers and viruses target those with a low centrality, which are weaker and more virus-prone. The danger is when the low-profile infected computer quietly infects a high-profile computer, causing the infection to spread. By identifying these high-risk, centrally low computers, viruses, similar to human diseases, can be quarantined and stopped from spreading.

The next step is further research, with mathematics playing a greater role in understanding the data. Sharabati plans on completing his research of social networks for his PhD degree. Beyond that, he is considering more research and perhaps an expansion into the world of online video game networks—particularly that of the World of Warcraft, which boasts 10 million players globally. "There's still a lot to do," he says with a chuckle.

Sharabati has been an instructor of statistics and mathematics at American University for four years. He received his master's degree from Minnesota State University in mathematics and computer science and is currently working on his PhD in computation mathematics with a concentration in social networks.



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