Rensselaer SCIENCE

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Researchers Reveal HIV Peptide's Pathway Into the Cell

Student has Sweet Success with Invention of Artificial Golgi

BIOTECHNOLOGY at Rensselaer

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DEAN'S LETTER

Welcome, once again, to our School of Science newsletter. This semi-annual publication is our way to inform you of all of the exciting progress we are making in the Rensselaer School of Science. Beginning this year, one issue will focus on a particular scientific topic and another will center on general coverage of School of Science activities. This issue focuses on biotechnology at Rensselaer.

Biotechnology has transformed all facets of the life sciences, from molecular to environmental, and from agriculture to understanding of human physiology. Biotech discoveries hold promise to cure major diseases such as Alzheimer's, diabetes, multiple sclerosis, AIDS, heart disease, and cancer. These discoveries may help solve the most challenging health issues of the 21st century.

Ranked among the world's most advanced research facilities, Rensselaer's Center for Biotechnology and Interdisciplinary Studies provides an ideal platform for collaborative research. The 218,000-square-foot, $80 million facility, which opened in 2004, is occupied by approximately 400 interdisciplinary researchers. Inside the Center, 60 high-tech laboratories provide a platform for collaboration among many diverse academic and research disciplines to enhance discovery and encourage innovation.

The research facilities include laboratories for molecular biology, analytical biochemistry, microbiology, imaging, histology, tissue and cell culture, as well as scientific computing and visualization. The Center contains an 800-MHz Nuclear Magnetic Resonance (NMR) spectrometer and the computing and visualization infrastructure needed to model molecular structure at the atomic level.

Rensselaer is committed to realizing the promise of biotechnology. In the near future, the Center for Biotechnology and Interdisciplinary Studies will be expanding. The Center will become home to a $22.5 million Gen*NY*sis Center for Bioengineering and Medicine funded by New York State, and a Center for Quantitative and Computational Bioscience, funded in part by a $750,000 federal grant.

The Center has drawn the best faculty and student researchers from around the globe, including those featured in this issue of Rensselaer Science, whose expertise span the foundation of biotechnology: biology, chemistry, mathematics, physics, and computer science; as well as chemical and biomedical engineering, and materials science. This diverse group meets under one roof to set the stage for collaborative research, share strategies, and discover the key to true innovation. Specifically, they focus on research translating into the development of new drugs for major diseases, tissue repair and replacement, and biosensors and monitoring for security and biohazard detection.

We hope you will enjoy this special issue of Rensselaer Science, highlighting the recent discoveries and innovations with Rensselaer's biological programs. The biotechnology research being performed at Rensselaer today will yield tangible benefits for health and medicine, national security, and the environment, the biggest challenges facing our society. Thank you again for your support and contributions to Rensselaer's School of Science as we work together to discover the key to true innovation.

Wei Zhao, Ph.D.
Dean, School of Science

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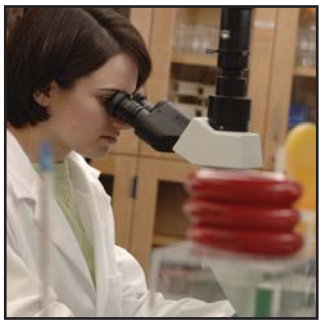


SCIENCE NEWS

On the cover: Doctoral student Angela Seggio uses a microscope to examine dissociated dorsal root ganglion cells in a laboratory at Rensselaer's Center for Biotechnology and Interdisciplinary Studies.

BIOTECHNOLOGY AT RENSSELAER

FOCUS ON SCIENCE

RECOGNITION AND OTHER NEWS

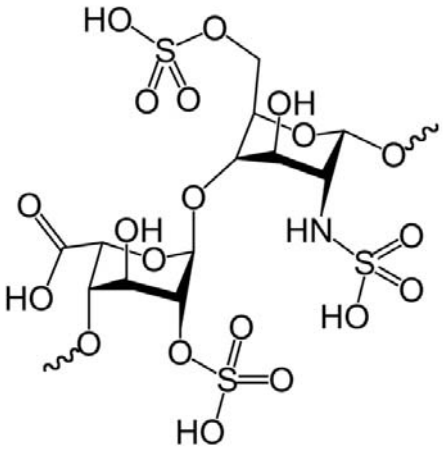
DEADLY Dose

Rensselaer Heparin Expert Helps Uncover Source of Lethal Contamination

The mysterious death of patients around the world following a routine dosage of the common blood thinner, heparin, sent researchers on a frantic search to uncover what could make the standard drug so toxic. A researcher at Rensselaer Polytechnic Institute was among a small group of scientists with the expertise and the high-tech equipment necessary to determine the source of the contamination.

Professor Robert J. Linhardt is part of an international team that recently announced it had uncovered the source of the deadly contamination. On April 23, the team led by researchers at the Massachusetts Institute of Technology (MIT), described the source in the journal Nature Biotechnology — a complex carbohydrate named oversulfated chondroitin sulfate, which has a structure so similar to heparin it was nearly undetectable to less advanced technology.

"Days after the deaths were first linked to heparin, we had the drugs in our hands from the FDA and our nuclear magnetic resonator (NMR) was set into motion to break down the structure of the drug and determine what could possibly be the source of the contamination," said Linhardt, Professor of Chemistry and Chemical Biology, the Ann and John H. Broadbent Jr. '59 Senior Constellation Professor of Biocatalysis and Metabolic Engineering, and the Acting Director of the Rensselaer Center for Biotechnology and Interdisciplinary Studies.



Heparin

"Now that we know the most likely source of the contamination, we are developing much stronger monitoring systems to ensure that this type of contamination is detected before it reaches patients," Professor Linhardt explained.

Although extremely close in chemical structure to heparin, the contaminant caused severe allergic reactions in many patients who were receiving routine treatment for kidney dialysis, heart surgery, and other common medical issues.

The researchers' extremely detailed structural analysis of the drug, using technology such as the NMR, was able to detect the minute differences between the contaminated drug and a normal dosage of heparin. While Linhardt and others are developing more sophisticated detection systems, Linhardt is also helping lead the race for a safer, man-made alternative to traditional biologic heparin. Biological heparin is currently developed by purifying the scrapings of pig and cow intestines.

"This contamination is unfortunately a sign that the way we currently manufacture

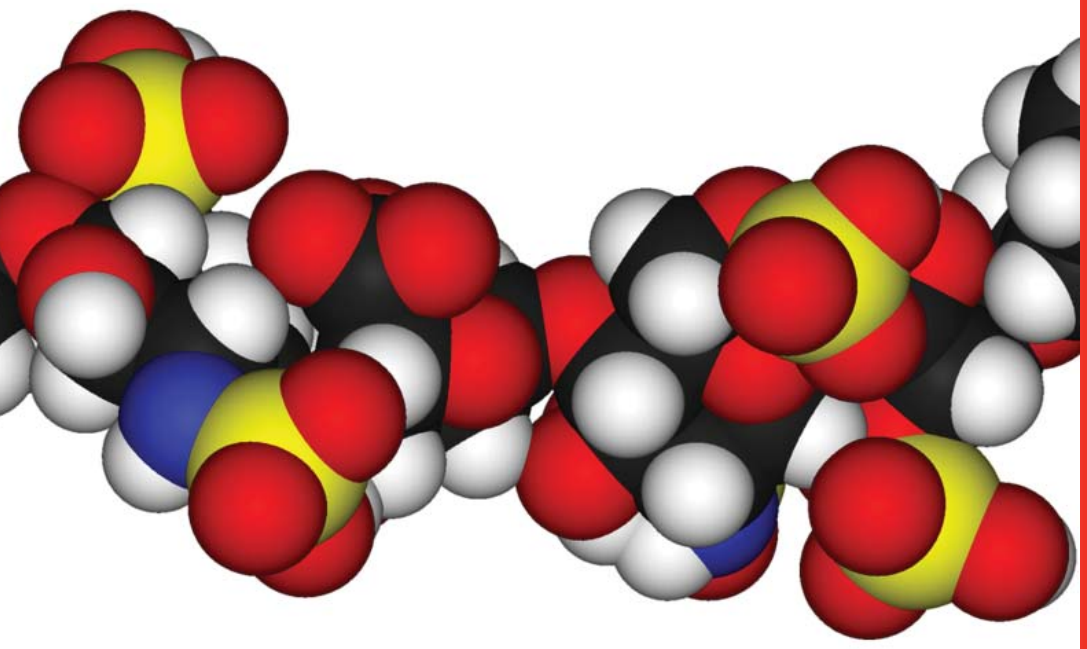
heparin is simply unsafe," he said. "Because we rely on animals, we open ourselves up for spreading prions and diseases like mad cow disease through these animals. And because most of the raw material is imported, we often can't be sure of exactly what we are getting."

Linhardt is helping lead the global race to develop a synthetic alternative to heparin that could help eliminate the potential for contamination and adverse effects of biologic heparin. His lab developed the first fully synthetic heparin in amounts large enough for human dosage in 2005, and he continues to work to get the product further tested and commercialized.

"A synthetic heparin is built using sugars and enzymes found in the human body," Linhardt said of his recipe for synthetic heparin. "So instead of taking pig intestines and trying to purify it over and over again to reduce it down to just heparin, we are building heparin from scratch with no foreign material present. This method ensures that we know exactly what is in the drug and have complete control over its ingredients."

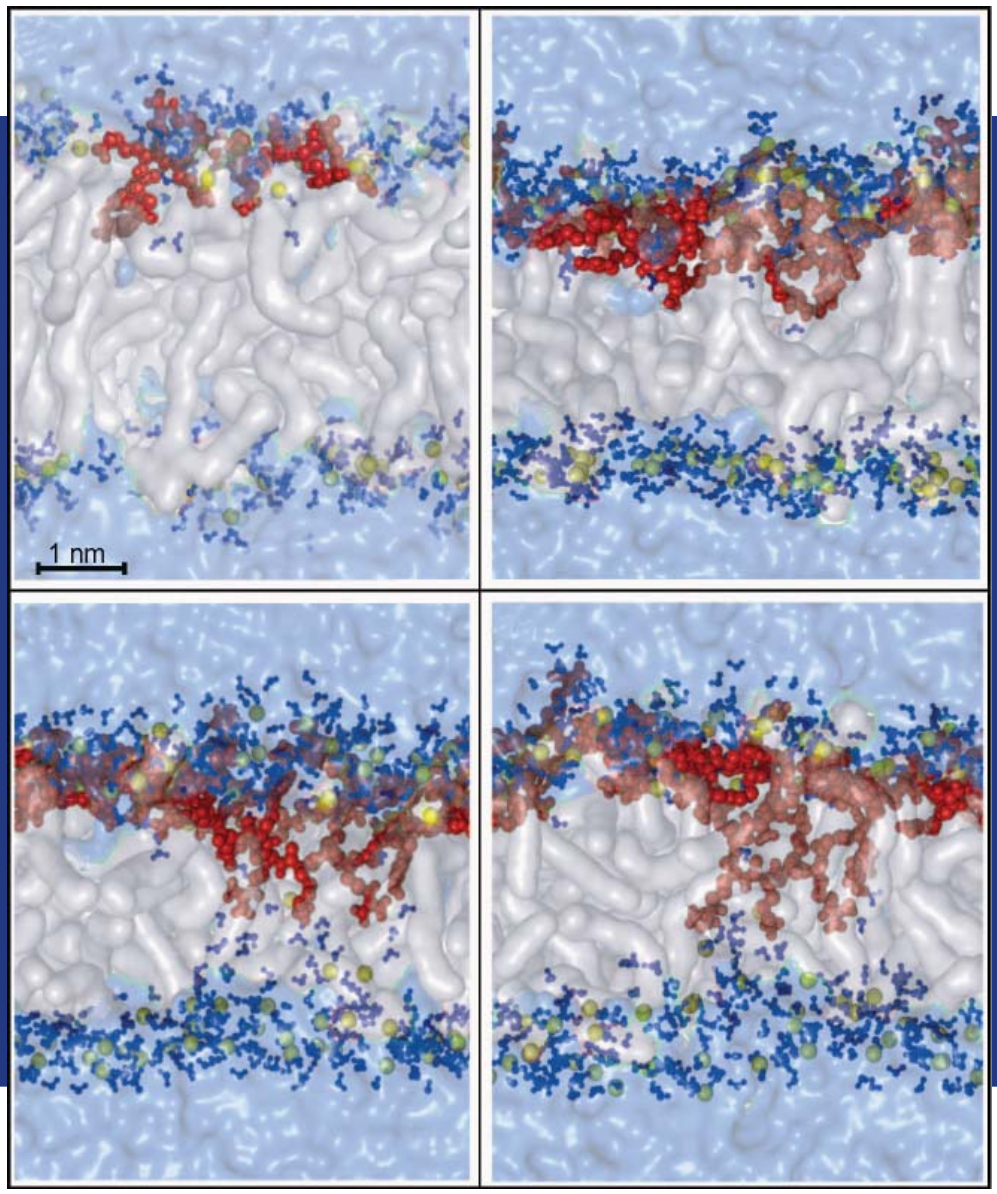
The research published in *Nature Biotechnology* was led by Ram Sasisekharan at MIT and involved a multidisciplinary and global team of researchers, including scientists and engineers from the FDA, Momenta Pharmaceuticals of Cambridge, Mass., and the Istituto di Ricerche Chimiche e Biochimiche of Milan, Italy.

Linhardt and his team of researchers at Rensselaer, which includes postdoctoral, graduate, and undergraduate students, used the sophisticated NMR and other technologies in the Rensselaer Center for Biotechnology and Interdisciplinary Studies to help uncover the source of the contamination.



"Instead of taking pig intestines and trying to purify it over and over again to reduce it down to just heparin, we are building heparin from scratch with no foreign material present. This method ensures that we know exactly what is in the drug and have complete control over its ingredients."

—Robert J. Linhardt
Professor of Chemistry and Chemical Biology



Researchers Reveal HIV Peptide's Possible Pathway **Into the Cell**

Two theoretical physicists at Rensselaer have uncovered what they believe is the long-sought-after pathway that an HIV peptide takes to enter healthy cells. The theorists analyzed two years of biocomputation and simulation to uncover a surprisingly simple mechanism describing how this protein fragment penetrates the cell membrane.

The discovery could help scientists treat other human illnesses by exploiting the same molecules that make HIV so deadly proficient.

The findings are detailed in the December 26, 2007, issue of the *Proceedings of the National Academy of Sciences (PNAS)*.

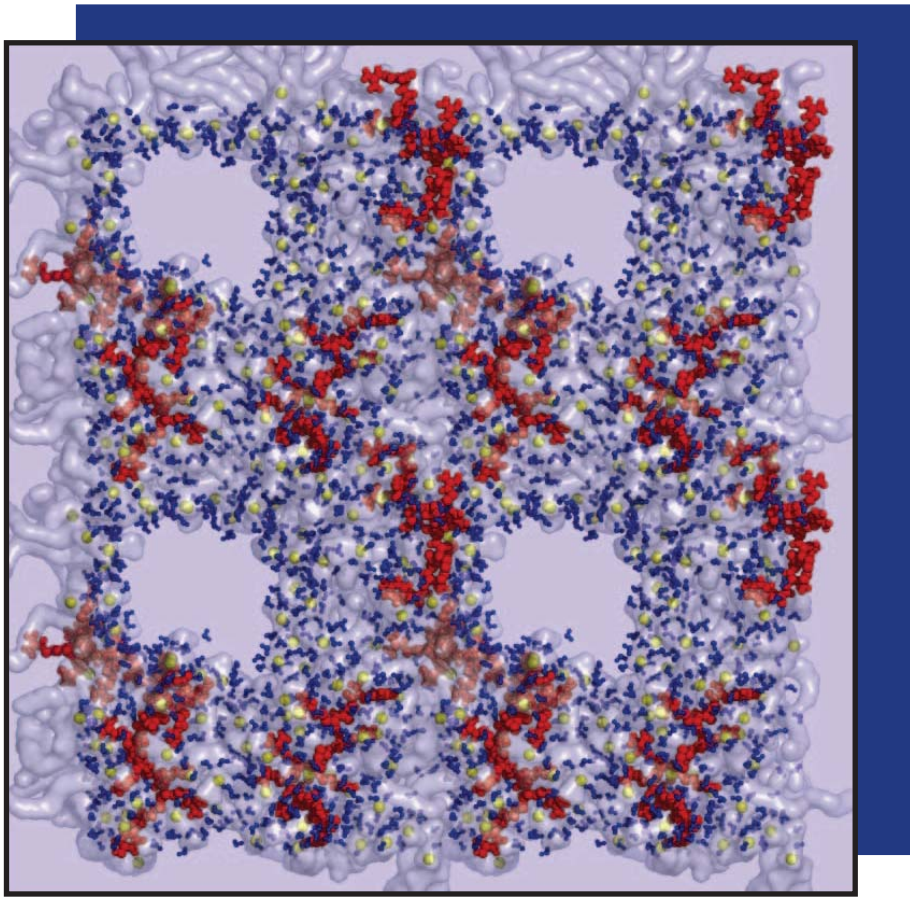
For the last decade, scientists have known that a positively charged, 11-amino-acid chain of HIV (HIV-1 Tat protein) can do the nearly unthinkable — cross through the cell membrane. Sometimes referred to as an "arrow protein," HIV-1 Tat pierces the cell membrane and carries a cargo though the cell membrane.

The researchers have discovered that the positively charged HIV peptide is drawn to negatively charged groups inside the cell membrane. When the HIV peptide cannot satisfy itself with the negative charges available on the cell membrane surface it is directly attached to, it reaches through the membrane to grab negatively charged groups in the molecules on the other side, opening a transient hole in the cell.

"What we saw in our computer calculations wasn't at all what we expected to see when we began," said co-lead author and Senior Constellation Professor of Biocomputation and Bioinformatics Angel Garcia.

Garcia and his collaborator, postdoctoral researcher Henry Herce, initially set out to uncover how the peptide interacts with a lipid bilayer that is used to model the cell membrane. A highly efficient biological system, the cell membrane is composed of a lipid bilayer, made up of two monolayers, designed to protect the cell by preventing the influx of material. Each lipid in the bilayer has a polar or charged end and a non-polar end. A monolayer of lipids faces the exterior of the cell, with the polar end facing the outside of the cell. Another monolayer is under the first layer, forming the bilayer. The polar end of the lower layer faces the interior of the cell, forming a middle section containing the uncharged halves of both monolayers.

Because charged particles seek each other in order to neutralize themselves and achieve a more stable state, the surface of the polar cell membrane and the positively charged HIV peptide are drawn to one another. But the interior of the bilayer is not charged and forms a strong barrier against the entrance of any charged material.



Special HIV peptide interacts with a cell membrane to open a hole in the cell, offering scientists a new pathway for delivering materials to a cell.

As was expected, in their simulations the researchers observed that the positive charges in the peptide quickly attached to the surface of the cell membrane and sought out and reacted with negatively charged phosphates from the charged portion of the lipid bilayer to satisfy their need for neutrality. "Then the peptide entered the forbidden territory of the cell," Garcia said. "This is when this mechanism starts to challenge conventional wisdom."

The researchers' model systems show the peptides grabbing for surrounding negative charges, but when no more of those charges are available due to their greedy peptide neighbors, some of the peptides reach into the cell membrane and grab negative charged phosphates from the other side. This opens a hole in the cell membrane and allows the flow of water and other material into the cell. Once all the peptides have been neutralized, the reaction stops and the hole closes, leaving behind a healthy, viable cell.

For the paper, the researchers reported a dozen different simulations run through a high-powered cluster of computers. Each simulation required a long process of testing and validating results. Garcia's computer cluster is now running simulations on the use of anti-microbial proteins which will open a pore in the cell and keep it open, killing the cell. Antimicrobial proteins have promising direct applications for killing harmful cells in the body.

The research was funded by the National Science Foundation (NSF) through the Rensselaer Nanoscale Science and Engineering Center for Directed Assembly of Nanostructures (NSEC) and Rensselaer.

RPI Student Has Sweet Success with Invention of ARTIFICIAL GOLGI

JEFFREY MARTIN has learned very quickly that a spoonful of sugar really does help the medicine go down. In fact, with his invention, the sugar may actually be the medicine.

Among the most important and complex molecules in the human body, sugars control not just metabolism but also how cells communicate with one another. Martin has put his basic knowledge of sugars to exceptional use by creating a lab-on-a-chip device that builds complex, highly specialized sugar molecules, mimicking one of the most important cellular structures in the human body: the Golgi Apparatus.

"Almost completely independently he has been able to come closer than researchers with decades more experience to creating an artificial Golgi," said Martin's adviser Robert Linhardt, Professor of Chemistry and Chemical Biology at Rensselaer. "He saw a problem in the drug discovery process and almost instantly devised a way to solve it."

Martin is enrolled in Rensselaer's Accelerated B.S./Ph.D. Program, which enables students to complete a bachelor's degree and a doctoral degree within six to seven years. "This program at Rensselaer has given me a priceless opportunity to work with some of the most renowned scientists in the country," said Martin, who received his B.S. in May 2008 and will continue on at Rensselaer as a graduate student, working with Linhardt to test and further develop his artificial Golgi.

Martin is also the recipient of a Barry M. Goldwater Scholarship. The scholarship was created to encourage outstanding students to pursue careers in mathematics, science, or engineering and to foster excellence in those fields.

THE GOLGI APPARATUS

Cells build sugars in a cellular organelle known as the Golgi Apparatus. Under a microscope, the Golgi looks similar to a stack of pancakes. The strange-looking organelle finishes the process of protein synthesis by decorating the proteins with highly specialized arrangements of sugars. The final sugar-coated molecule is then sent out into the cell to aid in cell communication and to help determine the cell's function in the body.

Martin's artificial Golgi functions in a surprisingly similar way to the natural Golgi, but he gives the ancient organelle a very high-tech makeover. His chip looks similar to a miniature checker board where sugars, enzymes, and other basic cell materials are suspended in water and can be transported and mixed by applying electric currents to the destination squares on the checker board. Through this process sugars can be built in an automated fashion where they are exposed to a variety of enzymes found in the natural Golgi. The resulting sugars can then be tested on living cells either on the chip or in the lab to determine their effects. With the chip's ability to process many combinations of sugars and enzymes, it could help researchers quickly uncover new sugar-based drugs.

HEPARIN AND THE GOLGI

Scientists have known for years that certain sugars can serve as extremely beneficial therapeutics for humans. One well-known example is heparin, which is among the most widely used drugs in the world. Heparin is formed naturally in the Golgi organelle in cells of the human body as well as in other animals such as pigs. Heparin acts as an anticoagulant preventing blood clots, which makes it a good therapeutic for heart, stroke, and dialysis patients.

The main source of heparin is currently the intestines of foreign livestock and as recent news reports highlight, the risk of contamination from such sources is high. Researchers are working around the clock to develop a safer,

man-made alternative to the drug that will prevent outside contamination. A synthetic alternative would build the sugar from scratch, helping eliminate the possibility of contamination.

"I am very grateful to have the privilege of working with Dr. Linhardt who has discovered the recipe to make fully synthetic heparin," Martin said. "Because we know the recipe, I am going to use it as a model to test the device. If our artificial Golgi can build fully functional heparin, we can then use the artificial organelle to produce many different sugar variants by altering the combination of enzymes used to synthesize them. Another great thing about these devices is that they are of microscale size, so that if needed we could fill an entire room with them to increase throughput for drug discovery."

There are millions of possible sugar combinations that can be formed and scientists currently only know the function of very few of them like heparin. "Since it is known that these types of sugars play a part in many important biological processes such as cell growth, cell differentiation, blood coagulation, and viral defense mechanisms, we feel that that this artificial Golgi will help our team to develop a next generation of sugar-based drugs, known as glycotherapeutics," Martin said. "We are going to start making new combinations and we simply don't know what we are going to find. We could find a sugar whose signal blocks the spread of cancer cells or initiates the differentiation of stem cells. We just don't know."

ACCELERATED B.S./PH.D. PROGRAM

Outstanding students in RPI's School of Science who have achieved a 3.5 or better grade point average at the end of their first year are invited to apply to the Accelerated B.S./Ph.D. Program where students complete their B.S. and Ph.D. degrees in a total of six to seven years from entrance to Rensselaer.

Students accepted into the program spend one or two semesters during their sophomore year doing research projects in two or three laboratories at Rensselaer to identify potential faculty mentors based on their research interests.

Once the students find the right laboratory, they continue research during the summers and subsequent academic years. Then they make a transition to graduate status at the beginning of, or during, the fourth year of study and continue the research that they started as an undergraduate. To learn more about the program visit www.rpi.edu/dept/science/accelerated/index.html.

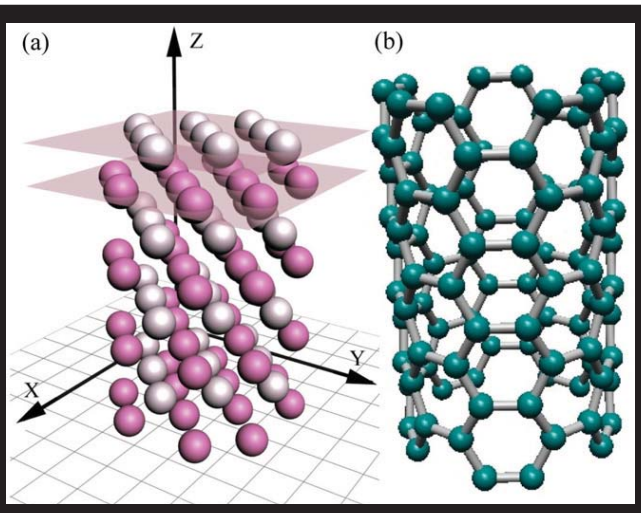
THE BARRY M. GOLDWATER SCHOLARSHIP PROGRAM

The Barry M. Goldwater Scholarship and Excellence in Education Program was authorized by the United States Congress in 1986 to honor Senator Goldwater and to foster and encourage excellence in science and mathematics. The purpose of the Foundation is to provide a continuing source of highly qualified scientists, mathematicians, and engineers by awarding scholarships to college students who intend to pursue careers in these fields. Each scholarship covers eligible expenses for undergraduate tuition, fees, books, room and board, up to a maximum of $7,500 annually. For more information, visit www.act.org/goldwater.

Carbon Nanotubes

Outperform Copper Nanowires as Interconnects

Researchers in Rensselaer's Department of Physics, Applied Physics, and Astronomy have created a road map that brings academia and the semiconductor industry one step closer to realizing carbon nanotube interconnects, and alleviating the current bottleneck of information flow that is limiting the potential of computer chips in everything from personal computers to portable music players.



(a) Diagram of the atomic structure of the copper nanowire. (b) Diagram of the atomic configuration of a single walled carbon nanotube.

To better understand and more precisely measure the key characteristics of both copper nanowires and carbon nanotube bundles, the researchers used advanced quantum-mechanical computer modeling to run vast simulations on a high-powered supercomputer. It is the first such study to examine copper nanowire using quantum mechanics rather than empirical laws.

After crunching numbers for months with the help of Rensselaer's Computational Center for Nanotechnology Innovations, the most powerful university-based supercomputer in the world, the research team concluded that the carbon nanotube bundles boasted a much smaller electrical resistance than the copper nanowires. This lower resistance suggests carbon nanotube bundles would therefore be better suited for interconnect applications.

"With this study, we have provided a road map for accurately comparing the performance of copper wire and carbon nanotube wire," said Saroj Nayak, an associate professor in Rensselaer's Department of Physics, Applied Physics, and Astronomy, who led the research team. "Given the data we collected, we believe that carbon nanotubes at 45 nanometers will outperform copper nanowire."

Because of the nanoscale size of interconnects, they are subject to quantum phenomena that are not apparent and not visible at the macroscale, Nayak said. Empirical and semi-classical laws cannot account for such phenomena that take place on the atomic and subatomic level, and as a result, models and simulations based on those models cannot be used to accurately predict the behavior and performance of copper nanowire. Using quantum mechanics, which deals with physics at the atomic level, is more difficult but allows for a fuller, more accurate model.

"If you go to the nanoscale, objects do not behave as they do at the macroscale," Nayak said. "Looking forward to the future of computers, it is essential that we solve problems with quantum mechanics to obtain the most complete, reliable data possible."

The size of computer chips has shrunk dramatically over the past decade, but has recently hit a bottleneck, Nayak said. Interconnects, the tiny copper wires that transport electricity and information around the chip and to other chips, have also shrunk. As interconnects get smaller, the copper's resistance increases and its ability to conduct electricity degrades. This means fewer electrons are able to pass through the copper successfully, and any lingering electrons are expressed as heat. This heat can have negative effects on both a computer chip's speed and performance.

Rensselaer graduate student Yu Zhou and postdoctoral research assistant Subbalakshmi Sreekala are co-authors of the paper. Materials science and engineering professor Pulickel Ajayan, who is now at Rice University, is also a co-author. The research results were featured in the March 2008 issue of *Journal of Physics: Condensed Matter*.

Funding for this project was provided by the New York State Interconnect Focus Center.

New Polymer Could Improve Semiconductor Manufacturing & Packaging

Researchers at Rensselaer Polytechnic Institute and Polyset Company have developed a new inexpensive, quick-drying polymer that could lead to dramatic cost savings and efficiency gains in semiconductor manufacturing and computer chip packaging.

Along with allowing enhanced performance and cost savings for conventional photolithography processes, the new material, called polyset epoxy siloxane (PES), should also enable a new generation of lower-cost, on-chip nanoimprinting lithography technology, according to the researchers.

“With this new material, chip manufacturers will be able to trim several steps from their production and packaging processes, and in turn realize a cost savings,” said Toh-Ming Lu, professor of physics, who oversaw the study. “PES is cheaper and more reliable.”

The widely adopted technique of photolithography involves using a mix of light and chemicals to generate intricate micro- and nano-scale patterns on tiny areas of silicon. As part of the process, a thin polymer film — called a redistribution layer, and crucial to the effectiveness of the device — is deposited onto the silicon wafer, in order to ease the signal propagation delay and to protect the chip from different environmental and mechanical factors.

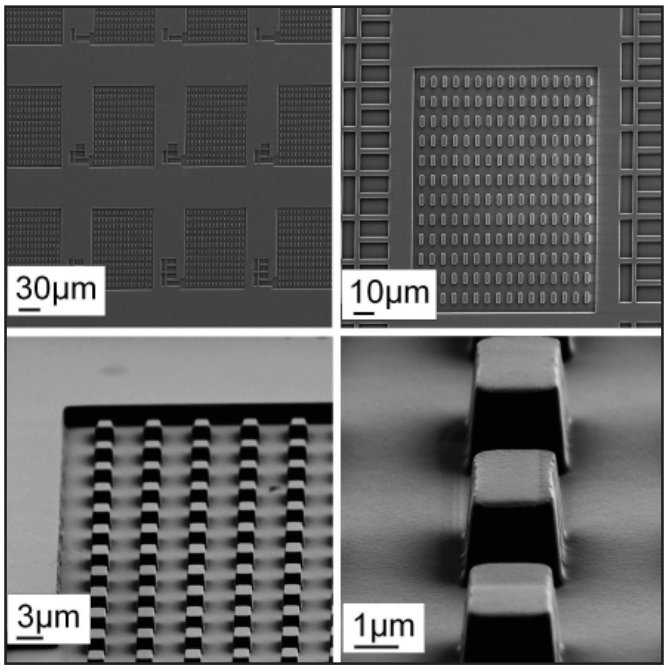
The new PES material developed by Lu’s group and Polyset Company is one such thin polymer film, and it offers several advantages over the incumbent materials typically used in the semiconductor manufacturing industry. In addition, their new PES material can also be used as a thin polymer film for ultraviolet (UV) on-chip nanoimprinting lithography technology, which is still in the early phases of development. The consistency of using PES in conventional technology, and then continuing to use PES while academia and industry test and gradually migrate to the next generation of devices, should help ease the transition.

“Having the ability to use one material — our new PES — for both photolithography and imprint will be very attractive to manufacturers,” Lu said. “At its core, our project is basic research, but it also has important industry implications. It’s very exciting.”

Manufacturers today typically use benzocyclobutene and polyimide as polymers for redistribution layers, because of their low water absorption, thermal stability, low curing temperature, low thermal expansion, low dielectric constant, and low leakage current. Lu said that PES offers significant advantages to these materials, particularly in the areas of cure temperature and water uptake.

PES cures, or dries and hardens, at 165 degrees celsius, about 35 percent cooler than the other two materials. The need for less heat should translate directly into lower overhead costs for manufacturers, Lu said. Another advantage of PES is its low water uptake rate of less than 0.2 percent, less than the other materials. Additionally, PES adheres well to copper and can easily be made less brittle if needed. All of these attributes make PES a promising candidate for redistribution layer application and UV imprint lithography.

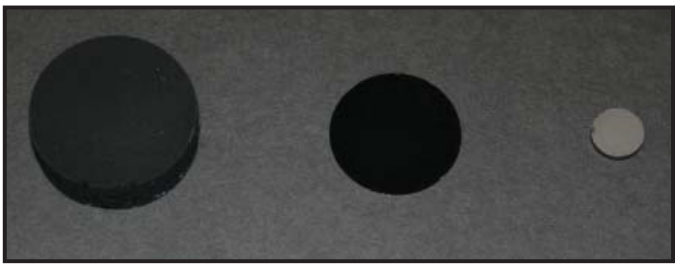
The project was funded through the New York State Foundation for Science, Technology and Innovation.



In this scanning electron microscope image of PES in a UV-imprint lithography application, the well-defined pattern indicates the material’s potential for use in next-generation chip manufacturing techniques.

Researchers Develop
Darkest Manmade Material

The new material, a thin coating comprised of low-density arrays of loosely vertically-aligned carbon nanotubes, absorbs more than 99.9 percent of light and one day could be used to boost the effectiveness and efficiency of solar energy conversion, infrared sensors, and other devices. The researchers received a Guinness World Record for their efforts.



The new darkest manmade material, with its 0.045 percent reflectance (center), is noticeably darker than the 1.4 percent NIST reflectance standard (left) and a piece of glassy carbon (right).

"It is a fascinating technology, and this discovery will allow us to increase the absorption efficiency of light as well as the overall radiation-to-electricity efficiency of solar energy conservation," said Rensselaer Polytechnic Institute professor of physics, Shawn-Yu Lin, who led the research project.

"The key to this discovery was finding how to create a long, extremely porous vertically-aligned carbon nanotube array with certain surface randomness, therefore minimizing reflection and maximizing absorption simultaneously."

All materials, from paper to water, air, or plastic, reflect some amount of light. Scientists have long envisioned an ideal black material that absorbs all the colors of light while reflecting no light, but have been unsuccessful in engineering a material with a total reflectance of zero.

The total reflectance of conventional black paint, for example, is between 5 and 10 percent. The darkest manmade material, prior to the discovery by Lin's group, boasted a total reflectance of 0.16 percent to 0.18 percent.

Lin's team created a coating of low-density, vertically aligned carbon nanotube arrays that are engineered to have an extremely low index of refraction and appropriate surface randomness, further reducing its reflectivity. The end result was a material with a total reflective index of 0.045 percent — more than three times darker than the previous record, which used a film deposition of nickel-phosphorous alloy.

"The loosely-packed forest of carbon nanotubes, which is full of nanoscale gaps and holes to collect and trap light, is what gives this material its unique properties," Lin said. "Such a nanotube array not only reflects light weakly, but also absorbs light strongly. These combined features make it an ideal candidate for one day realizing a super black object."

"The low-density aligned nanotube sample makes an ideal candidate for creating such a super dark material because it allows one to engineer the optical properties by controlling the dimensions and periodicities of the nanotubes," said Pulickel Ajayan, the Anderson Professor of Engineering at Rice University in Houston, who worked on the project when he was a member of the Rensselaer faculty.

"It's also interesting to note that the reflectance of our nanotube array is two orders of magnitude lower than that of the glassy carbon, which is remarkable because both samples are made up of the same element — carbon," said Lin, who is also a member of Rensselaer's Future Chips Constellation.

This discovery could lead to applications in areas such as solar energy conversion, thermalphotovoltaic electricity generation, infrared detection, and astronomical observation.

Other researchers contributing to this project and listed authors of the paper include Rensselaer physics graduate student Zu-Po Yang, Rice postdoctoral research associate Lijie Ci, and Rensselaer senior research scientist James Bur.

The project was funded by the U.S. Department of Energy's Office of Basic Energy Sciences and the Focus Center New York for Interconnects.

Web Language
Gains International Recognition

Gregory Williams, a Rensselaer doctoral student in computer science who works in the new Tetherless World Constellation, single-handedly implemented a Web language that allows Web sites to speak and share data with one another. His language was given high marks by the World Wide Web Consortium (W3C) and will form a baseline for other companies and researchers to build upon.

In the great wilderness of the World Wide Web, billions of Web sites have been created, each with their own underlying programming language. With no universal language, Web sites simply can not communicate with each other and share data. To solve these virtual communication gaps, the World Wide Web Consortium (W3C) issued a web language standard called SPARQL (pronounced “sparkle”) on Jan. 15, 2008 that allows Web sites to share data with one another and effectively speak the same language.

The SPARQL standard includes several different implementations that were developed by companies, university research teams, and individuals. Each implementation was then rated by W3C. William’s SPARQL implementation was among the top five languages. With standard base languages like his in place, programmers and researchers can build upon the standards to develop Web sites and technologies that can easily share data with each other in the Semantic Web.

“The Semantic Web allows computers to interact without the need for human interpretation,” said James Hendler, senior chair of the Tetherless World Constellation. “Currently the Web is written to look pretty for human eyes to read, but computers cannot read it in the same way as a person. The Semantic Web makes that information more readable to the computer and it makes the information more readable to another Web application. SPARQL will be the base language for sharing data on the Semantic Web.”

“My motivating base was to implement a version of SPARQL that was easy to use and access so researchers can quickly introduce themselves to the language and then begin playing with it,” Williams said. “I hope this will allow researchers to quickly extend the language and continue to do new things on the Web.”

William’s open source language has already received high marks from top companies looking to use SPARQL such as IBM, Oracle, and Hewlett-Packard. The SPARQL standard helps advance the research mission of the Tetherless World Constellation at Rensselaer. The constellation, led by Hendler, one of the founders of the Semantic Web, and top Web language expert and constellation chair Deborah McGuinness, strives to understand and advance the Web and Web technology. The Semantic Web allows people and computers to seamlessly interact and share information with one another regardless of programming, language, or operating system.

“With SPARQL, the constellation and researchers around the world can start to build Web sites that can easily access each other,” Hendler said. “Soon we could have a Web where your Facebook and MySpace pages interact, you can plan your travel across dozens of Web sites, and buy a series of books where each book in the series is purchased from a different Web site.”

To learn more about the
Tetherless World Constellation
go to http://tw.rpi.edu

SCIENCE Recognition

TOH-MING LU, the R.P. Baker Distinguished Professor of Physics at Rensselaer Polytechnic Institute, has been named a lifetime fellow of the Materials Research Society (MRS). The MRS has recognized Lu for his contributions to the advancement of materials research, specifically his "seminal contributions to the fundamental understanding of thin film morphological evolution."

This is the first year that MRS has named a class of fellows. Lu joins a distinguished group that includes 34 researchers for their outstanding contributions to the field. He was formally honored during the 2008 MRS Spring Meeting on March 26, 2008 in San Francisco, California.

A nanomaterials expert, Lu's research strives to develop new, high-performing nanostructures that can be used in integrated electronics, semiconductors, and energy storage devices. His lab uses new approaches to develop unique nanostructures and analyze those structures as they grow. His imaging and analysis techniques allow researchers to fully understand how and why different growth techniques grow nanomaterials in very specific ways. His lab is also developing techniques that deposit ultra-thin layers of conductive metals and dielectrics onto surfaces to develop new, super-fast and efficient electronics and nanodevices.

Lu joined Rensselaer in 1982. He is a fellow of the American Association for the Advancement of Science, the American Physical Society, and the American Vacuum Society. He is author of more than 400 technical papers and holds nine patents related to his research.

The Materials Research Society, established in 1973, strives to create links between researchers working in the field of materials science. For more information, visit www.mrs.org.

FENGYAN LI, assistant professor of mathematical sciences at Rensselaer Polytechnic Institute, has been named a 2008 Alfred P. Sloan Research Fellow. Li is among a group of 118 fellows from 64 colleges and universities in the United States and Canada who have been recognized for conducting research at the frontiers of physics, chemistry, mathematics, neuroscience, economics, computer science, and computational and evolutionary molecular biology.

"The Sloan Research Fellowships support the work of exceptional young researchers early in their academic careers, and often at pivotal stages in their work," said Paul L. Joskow, president of the Alfred P. Sloan Foundation, in a press release announcing this year's fellows. "I am proud of the foundation's rich history in providing the resources and flexibility necessary for young researchers to enhance their scholarship, and I look forward to the future achievements of the 2008 Sloan Research Fellows."

The fellowship is awarded for a two-year period and carries a grant of $50,000.

Li's research focuses on the design, analysis, and implementation of computer algorithms for solving problems arising in science and engineering. Her current work involves the development of the local-structure-preserving discontinuous Galerkin methods, the design of reliable and efficient methods in computational electromagnetism, as well as the fast algorithms for solving steady-state Hamilton-Jacobi equations. Her research has applications in many areas including weather forecasting, pollution control, energy physics, communication, image processing, and computer vision. Results from Li's research have been published in the *Journal of Computational Physics*, *SIAM Journal on Numerical Analysis*, *Journal of Scientific Computing*, and several other publications.

More information on the Alfred P. Sloan Foundation can be found at www.sloan.org.

SHENGBAI ZHANG, a quantum physicist renowned for his computational modeling and research in semiconductor defects, has been named senior chair of Rensselaer's Gail and Jeffrey L. Kodosky '70 Constellation in Physics, Information Technology, and Entrepreneurship.

Zhang joined Rensselaer on January 1, 2008. The first to hold the constellation position, Zhang also is a professor in the Department of Physics, Applied Physics, and Astronomy.

His research goal is to use quantum-mechanical computations to discover solutions to some of today's most pressing challenges in technology, security, sustainable energy, and the environment. Zhang comes to Rensselaer from the National Renewable Energy Laboratory (NREL), where much of his recent research focused on breaking technology barriers to alternative sources of energy, including hydrogen. He also has conducted extensive research in nanophysics, doping physics, surface physics, interface physics, high-pressure physics, and many-body physics.

Constellations are multidisciplinary teams of faculty and students designed to help Rensselaer attract and retain exceptional researchers and achieve global impact.

According to Zhang, the opportunity to head and help shape the Kodosky Constellation played a key role in his decision to come to Rensselaer. Endowed by Gail Theilmann Kodosky and Institute Trustee Jeffrey Kodosky '70, the Kodosky Constellation will focus on energy conversion, future electronics, nano sciences, and a broad range of other cutting-edge areas of inquiry, including cyber-based physics and science discovery.

"I see a dynamic change at Rensselaer, a commitment to make tomorrow brighter than today," Zhang said. He pointed to considerable investments in facilities and technology, especially the Computational Center for Nanotechnology Innovations.

"Rensselaer has the world's most powerful university-based supercomputer so, in computational physics, we're working in cyberspace in a way that was not possible before," Zhang said. "We have the ability to test aspects of natural law that, until now, have not been observable.

"This is where I anticipate some of our most exciting discoveries," he said. "For the first time, we will be able to apply these natural laws to technology and to affect the real world — to meet national needs for alternative energy and to provide solutions to other urgent concerns."

WILFREDO COLÓN, associate professor of chemistry and chemical biology, has been elected fellow of the American Association for the Advancement of Science (AAAS).

Colón is cited for "distinguished contribution to the understanding of protein folding and misfolding, and for his encouragement of underrepresented minority students into careers in science."

Colón's research focuses on proteins and the chemical and physical principles that cause them to acquire and retain their functional three-dimensional structure, a process known as folding. Colón's lab is studying the structural mechanisms of protein folding and working to understand the molecular basis for why certain proteins misfold. His ultimate goal is to facilitate the rational design of therapeutics for protein misfolding diseases such as Lou Gehrig's disease, type II diabetes, Parkinson's disease, and Alzheimer's disease. Colón is an active educator who works to encourage students from underrepresented minorities to pursue successful careers in science. Colón joined RPI in 1997.

SCIENCE Recognition

JAMES HENDLER professor of computer science and senior constellation professor of RPI's Tetherless World Research Constellation was asked to serve on the newly formed NSF Network Science and Engineering Advisory Committee, which will work with the NSF and the Computer Research Association on creating a research agenda for this emerging area. Hendler specializes in the emerging field of Web science, which encompasses understanding the Web in its full richness, exploring the underlying technologies that make it work and its social and policy implications, and developing new technologies to expand the Web and make it more useful.

GEORGE PLOPPER associate professor of biology, has been awarded the 2008 Trustees Outstanding Teacher Award, which recognizes outstanding accomplishments in classroom instruction, and consists of a $10,000 honorarium. Selection is based on evidence of sustained outstanding teaching as reflected by student evaluations from the last two years, peer evaluations, and letters of support from colleagues, alumni, students, and administrators. Dr. Plopper's research interests include cell-extracellular matrix interactions, cell signaling, stem cell biology, cancer cell biology, and tissue engineering.

VOLKAN ISLER assistant professor of computer science, received a 2008 National Science Foundation Faculty Early Career Development (CAREER) Award of more than $80,000 for his project: Mobility Control for Robotic Sensor Networks. His project focuses on the development of mobility strategies for Robotic Sensor Networks (RSNs) — networks of robots equipped with communication, computation and sensing capabilities.

For RSN technology to be utilized in critical applications such as emergency response and environmental monitoring, mobility algorithms for operation in dynamic and complex environments are needed. In this project, three novel mobility problems which arise in many RSN applications are introduced. This work will focus on solving these mobility problems which will yield provably correct solutions for numerous RSN applications. In addition, bounds on the performance of a given RSN in fundamental problems such as tracking, collaborative sensing and estimation will be established.

The output of this research will be a significant step toward enabling the use of fully autonomous RSNs for crucial applications in emergency response, energy and environmental monitoring, and health care automation. Sensing and actuation play important roles in the evolution of information technology. The project will contribute to this evolution through the development of novel distributed sensing and control algorithms.

BRIAN SCHULKIN graduate student in physics, has been nominated for the 2008 TR35 list, *Technology Review* magazine's awards list honoring the world's top young innovators. Established in 1999, the TR35 list recognizes 35 outstanding innovators under the age of 35 each year. *Technology Review* is owned and published by MIT.

THE UNDERGRADUATE RESEARCH FORUM AND AWARDS CEREMONY was held on March 28. Three students in the School of Science won awards:

ASHLEY THOMAS
Mathematics, First Place, Applied Category, "Inverse Problems in Sonoelastography: Recovering the Shear Wave Speed from Crawling Wave Data."

JAMES RAJOTTE, Biology, First Place, Theoretical Category, "Observation of Phosphoinositol Lipid-Septin Interactions Through GST Fusion Proteins."

MEGAN SALT, Biochemistry and Biophysics, Third Place, Theoretical Category, "The Role of Rho Family GTPases in Microtubule Organization During Epithelial Polarization."

More info --> *www.eng.rpi.edu/urfa*

THE FORTY-FIFTH ANNUAL FACULTY RECOGNITION DINNER

held on April 28, included the presentation of gifts for years of service and retiring faculty. Five School of Science professors received awards:

MICHAEL HANNA, associate professor of biology, 30 years of service.

MARK HOLMES, professor of mathematical sciences, 30 years of service.

DONALD DREW, professor of mathematical sciences, 35 years of service.

JOSEPH ECKER, the EP Hamilton Distinguished Professor of Mathematical Sciences, 40 years of service.

CARL MCDANIEL, professor of biology, is retiring this year and was given recognition for over 30 years of service.

Faculty Recognition Dinner Photos --> *www.rpi.edu/news/events/frd08/index.html*

School of Science Artists at the annual awards reception: Heidi Newberg, associate professor of physics, applied physics and astronomy; and physics graduate student Benjamin Willett.

THE SCHOOL OF SCIENCE AWARDS RECEPTION

was held on May 1 in the atrium of the Center for Biotechnology and Interdisciplinary Studies. Attendees enjoyed hors d'oeuvres, door prizes, and a fine art show. Dean Wei Zhao gave the opening welcome, and award presentations were given by Associate Dean William Siegmann and other members of the School of Science.

The award recipients are:

RYAN BADEAU, Physics, Applied Physics, and Astronomy, Outstanding Undergraduate Student.

BRIAN SCHULKIN, Physics, Applied Physics, and Astronomy, Outstanding Graduate Student.

YILIN YAN, Biology, Outstanding Graduate Student.

DAVID HOLLINGER, Computer Science, Outstanding Teaching.

DOUGLAS SWANK, Biology, Outstanding Early Research.

KAREN COONRAD, Chemistry, Outstanding Staff Service.

Other awards include the 2008 Poster-Palooza Winners: Shreya Chad, Apirak Hoonlor, Kelly Perry, and Dustin Trail; and the School of Science Artists Recognition: Michael Aldersley, Toh-Ming Lu, Heidi Newberg, Paul Stoler, Nagamani Sukumar, and Benjamin Willett.

ALUMNI NEWS

DORK SAHAGIAN (left) who earned a bachelor's degree in physics from RPI in 1977, and **ROBERT SCHOCK** (right) who earned a Ph.D. in geology in 1966, are part of the organization that received the 2007 Nobel Peace Prize. The alumni are part of the Intergovernmental Panel on Climate Change (IPCC), which shared the international peace prize this past year with Al Gore, environmental policy leader and former U.S. vice president.

The organization and its contributing scientists were honored by the Nobel Foundation "for their efforts to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change."

Sahagian is currently a professor of earth and environmental sciences and director of the Environmental Initiative at Lehigh University. Schock is director of studies for the World Energy Council (WEC) in London as well as a consultant to industries and governments worldwide.

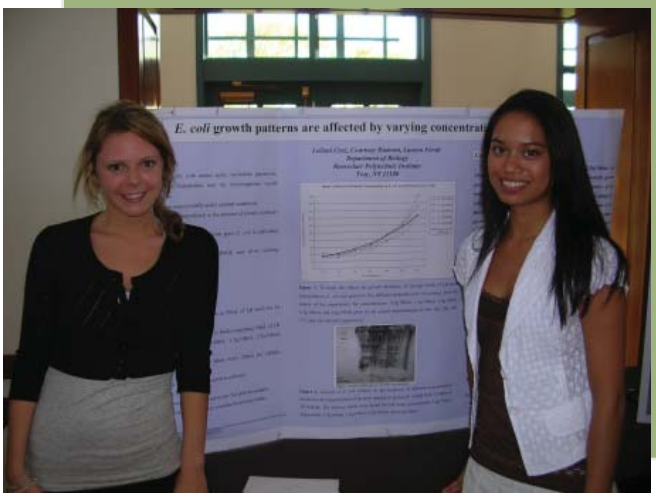
The IPCC was established in 1988 by the United Nations Environment Programme and the World Meteorological Organization. The Nobel Peace Prize has been awarded to 95 individuals and 20 organizations since its inception in 1901.

Spring
Poster Sessions

Poster events are not only fun — they are good experience in preparation for students' future careers in the world of science. On April 24, students from Introduction to Cell Biology took part in a poster session, organized by laboratory supervisor George Edick of the Department of Biology. "The posters culminate the in-class research projects that were performed by the students," Edick said. Approximately 140 students participated in the event.

Students filled the Heffner Alumni House, energetically discussing the work they completed over the course of the semester. "The students were eager to discuss the findings of their research projects, and the format of a poster session prepares them for an activity that most of them will be repeating throughout their careers," Edick explained.

A similar event, Poster-Palooza, was held at RPI's Empire State Hall on April 17. This interdepartmental research colloquium and poster session, organized by the School of Science Graduate Student Council, was attended by over 100 students and faculty, including Wei Zhao, Dean of Science; Samuel C. Wait Jr., Associate Dean of Science; and William L. Siegmann, Associate Dean of Science for Graduate Education and Research.



"I was delighted and inspired by the energy and enthusiasm at the event," Professor Siegmann said. "The School of Science Graduate Student Council was recently formed by Dean Zhao, and the students through their hard work and strong leadership, planned and developed this event and made it a great success."

"Our goal in planning this event was to foster relationships, both personal and professional, among students in RPI's School of Science. The session was a great success with 43 participants from 8 departments," said Scott LeFevre, a member of the Graduate Student Council. "Poster-Palooza was the first function undertaken by the newly formed council and we look forward to providing similar events in the future."

Members of the council include Mary Abercrombie, Sarah Broderick, James Gatewood, Asif Javed, Scott LeFevre, Jeff Martin, Ya Ou, and Sanchay Subhedar.

Rensselaer Annual Fund

Our mission in the School of Science is simple: Rensselaer seeks students interested in science. These students may become scientists and researchers, or they may be students who recognize that a science education is an excellent starting place for a wide variety of careers. These talented students will become doctors and lawyers, or go into business, finance, public service, or other rewarding careers.

The common thread is that all of our students are excited about the importance of science and technology. They recognize that the "big issues" society will face in the new century will be heavily science-based. Rensselaer is committed to attracting the next generation of scientists and leaders in their chosen fields. While the 21st century presents many challenges, Rensselaer is uniquely poised to meet them. Primary among them is educating the young leaders and global citizens of tomorrow. Your support of the Rensselaer Annual Fund is essential to this mission.

The Rensselaer Annual Fund offers a foundation for a world-class undergraduate science education, including exciting opportunities for undergraduate research and an interdisciplinary science education. Your gift to the Annual Fund helps to provide an environment that fosters innovation, discovery, and knowledge for the next generation of global leaders in science and technology.

The support of our alumni, parents, and friends enables us to provide these opportunities for our students. But we cannot do it without you.

As a graduate of the School of Science, your gift to the Rensselaer Annual Fund can directly impact our ability to expand our offerings to our students. Just as important, alumni participation is one of the factors that ranking organizations, such as U.S. News & World Report, consider in determining a university's position. By participating today, you will have a positive effect on our rankings, while influencing the value of your degree.

Will you join us by making your gift today? Your gift to the Annual Fund gives you a stake in the future of our talented science students and in the future of Rensselaer. Please visit our secure Web site: www.alumni.rpi.edu/give or call (518) 276-2564 to make your gift. Thank you.

School of Science Initiatives

1. Carol D. and Samuel C. Wait, Jr. '53 Undergraduate Research Scholars Fund
Your gift to this fund will help endow a program initiated with a $50,000 gift from the Waits to support summer stipends for undergraduates to participate in science research projects.

2. George Janz Fund for Undergraduate Research in Chemistry
Donald S. McMurtry '86 has honored longtime Chemistry Professor George J. Janz through the creation of this fund. Your gift will expand the number of stipends offered to chemistry students to work with a faculty member on research and also attend a scientific conference.

3. Dr. Joseph E. Flaherty Lecture Series in Computer Science
Marty Schoffstall '82 has created a $100,000 Challenge to School of Science alumni to endow a lecture series in computer science to honor Dr. Joseph E. Flaherty on the occasion of his retirement as Dean of Science. Marty will match all alumni gifts up to $100,000 to expose students to world-class minds in this field.

For information on how you can contribute to one of these funds, please contact Kristi Jongeling at jongek@rpi.edu or (518) 276-3958. If you wish to give online, visit www.alumni.rpi.edu/give and designate the fund you wish to support.

Rensselaer SCIENCE

Ranked among the world's most advanced research facilities, the Rensselaer Center for Biotechnology and Interdisciplinary Studies provides a state-of-the-art platform for collaborative research.

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