Super-adhesion: no longer just for geckos

Polymer scientist Alfred Crosby and biologist Duncan Irsich have collaborated to develop a new class of adhesive devices that have an unprecedented combination of properties to allow for supporting high-weight objects, and even climbing. Inspired by nature and the climbing abilities of the Gecko, the team created “Geckskin,” a new material that when fabricated as a device the size of an index card can hold up to 700 pounds while adhering to a smooth surface. The material, which can be produced at low cost with commercially available materials, can be released with a gentle tug and be reused many times with no loss of effectiveness and no surface damage or messy residue. Geckskin has generated significant interest from both companies and investors. This technology represents a breakthrough in the design and development of nature-inspired adhesives on macroscopic length scale with “gecko-like” attributes. The potential applications of the technology in the home, medical, and industrial sectors are enormous. Applications include consumer and home products, industrial material handling, exercise equipment, and medical accessories.

The Q Microbe®: patented technology streamlines production of biofuels

Microbiology professor Susan Leschine describes her vision for the day when clean, renewable, and local resources fuel motor vehicles that restore and preserve the health of the planet. Leschine is a leading authority on cellulose-digesting microbes, their role in the global carbon and nitrogen cycles, and their industrial applications. For the last 25 years, Leschine has directed a research program on microbes and microbial communities that decompose plant biomass. Her research led to Marlborough, MA start-up Qteros, Inc., whose patented technology converts cellulose from non-food-based biomass into ethanol. The Q Microbe® that Leschine and colleague Thomas A. Warnick discovered over ten years ago is a natural bio-refinery, producing ethanol as part of its metabolism as well as possessing a number of other unique characteristics that together dramatically streamline the low-cost production of cellulosic ethanol. Currently, UMass Amherst is collaborating with the Indian firm Praj Industries on further development of improved microbial strains and culture media to achieve higher process efficiencies and yields of ethanol and other chemicals derived from cellulosic sources such as corn cobs or bagasse.

When tornadoes strike, UMass Amherst is there

When tornadoes, land falling hurricanes, and other hazards strike, storm spotters and emergency managers now have a better tool to predict, detect, and alert people to severe weather. A new radar system developed by UMass Amherst engineers in the Center for Collaborative, Adaptive Sensing of the Atmosphere (CASA) gives national weather forecasters, for the very first time, a way to see places in the atmosphere where severe weather starts. With a view closer to the ground, forecasters can more precisely detect storms, determine their severity, and more quickly get information out to those in the path of the storm. CASA is now tackling the system’s public safety, security and economic benefits in a densely populated, urban environment. In collaboration with the North Central Texas Council of Governments, CASA will soon deploy a next-generation weather sensing and forecasting system for the 16-county Dallas Fort-Worth Metropolis, an area with 6.5 million people that has plenty of volatile weather. The CASA DFW Weather Net will include 8 smart radars networked to provide public safety officials and businesses minute-by-minute, neighborhood-scale information about developing weather threats in real-time. Bill Bunting, chief meteorologist for the National Weather Service in Fort Worth, has been quoted in the press as saying “the near-ground radar system, which will supplement the current NEXRAD Doppler radar network, will provide faster scans, higher-resolution images and multiple overlapping views of storm cells.”

Distractology 101: a crash course in distracted driving

Distracted driving crashes kill more than 5,000 people a year. Engineering faculty at the University of Massachusetts Amherst have teamed up with Arbella Insurance Group Charitable Fund to do something about it. Arbella is sponsoring research conducted by Dr. Donald Fisher, professor and head of the Department of Mechanical and Industrial Engineering, who is a national expert on distracted driving. Fisher found that real-life scenarios are the best way to teach new drivers how to avoid accidents and stay safe at the wheel. Together, UMass and Arbella created Distractology 101, a mobile classroom and driving simulator that travels to select communities throughout lower New England as part of a free tour that trains new drivers on how to anticipate hidden hazards, react to the road and avoid accidents. According to Fisher, evaluations of the program suggest that it makes novice drivers substantially more likely to engage in behaviors that will help them avoid crashes. Compared with untrained novice drivers who fail to anticipate hazards 40 percent of the time, program participants fail only 10 percent of the time. “That’s powerful evidence for the benefits of education,” notes Fisher.

UMass chemists develop biosensors to detect bacteria

Led by Chemistry Professor Vincent Rotello, a team of UMass Amherst researchers has developed a pocket-sized, paper sensing strip using nano biosensors that when dipped into water detects trace amounts of bacteria. Because nanoparticles are so small, they are ideal for binding to biological compounds. When the strip is placed in water, any bacteria in the water start to bind with the nanoparticles, removing them from the enzymes. As the enzymes are freed, chemical processes turn the strip a bright red color, indicating that bacteria are present and the water is not drinkable. The new technology may prove to be an invaluable tool in the developing world where more than one billion people do not have access to clean, safe drinking water and millions die each year from water-borne diseases. The strips are easy and inexpensive to produce—Rotello’s students use an inkjet printer to make them. Taking regular ink cartridges, they remove the ink and replace it with the materials. Ink cartridges are equipped with four channels (more than enough for the necessary compounds), one for each color: cyan, magenta, yellow, and black. Students place the nanoparticles in one channel, the substrate in another and the enzyme in a third in the ratio that they need.
Electronic signposts and other perfections

The world’s 300 million people with blindness or impaired vision due either to eye diseases or uncorrected refractive errors encounter problems in independent living because of their reduced perception of the environment. And new environments pose a huge challenge for them to perceive their surroundings without seeking help from others. Professor Aura Ganz, electrical and computer engineering, has developed an electronic system called PERCEPT, designed to allow visually impaired individuals to navigate unfamiliar buildings with ease. With a $380,000 grant from the National Institutes of Health/National Eye Institute, PERCEPT is generated using radio frequency identification (RFID) tags placed throughout a building as audio landmarks. When visually impaired visitors tune into these “electronic signposts” with their RFID reading devices the system feeds back verbal instructions. Partners in this work include the Massachusetts Commission for the Blind, U. S. Department of Veterans Affairs, the Carroll Center for the Blind, the Perkins School for the Blind, and the Guiding Eyes for the Blind, an internationally accredited guide dog school.

Microbes have campus partner thinking trashcan to gas can

UMass Amherst and Rutland, Vermont-based ReCommunity Holdings are partnering on research programs that use microbes to digest household trash and turn it into fuel. The company has committed $635,000 to The Institute for Massachusetts Biofuels Research (TIMBR) at UMass to develop methods of turning waste into useable substances such as ethanol or low-emission substances that could be burned in power plants. ReCommunity partners with municipalities to recover discarded natural resources destined for landfills and convert them into clean, efficient and cost-competitive commodities, products, and energy. The company is sponsoring projects led by Professors Paul Dauenhauer, Michael Henson, Susan Leschine and Jeffrey Blanchard in the fields of chemical engineering and life sciences to develop extraction and conversion strategies for materials from municipal solid waste streams that can become feedstocks for industry and energy production. The UMass researchers are learning how to optimize these processes for efficient production of sustainable feedstocks for the energy, transportation fuels and industrial chemicals industries, as well as how to customize additives to reduce the emissions of electric power plants that currently use conventional energy resources such as coal.

Developing tools to stop plague and other bacterial threats

UMass Amherst biochemist Alejandro Heuck recently received a five-year, $950,000 grant from the National Institutes of Health to map the molecular structure of a needle-like tool used by deadly bacteria to drill holes in mammalian cell walls. Once a channel is open, bacteria that cause such diseases as bubonic plague, dysentery, and food poisoning pump proteins in to destroy the body’s ability to fight infection, killing millions of people each year worldwide. Heuck expects this advance will help identify new targets for developing new drugs and treatment avenues. Further studies will build on a breakthrough reported last year by graduate student Fabian Romano and Heuck who were able to characterize enough of the bacterial needle to build a model membrane system for further experiments. This will let them study how the molecular machine pores holes in cell walls of warm-blooded animals and humans to inject the toxic proteins.

Hope for Fabry disease

Professor Scott Garman and his research team are much closer to understanding the origin of protein-folding disorders such as Alzheimer’s, Parkinson’s and Huntington’s diseases, and with that, hope for a promising new treatment for Fabry disease. People born with Fabry disease have a faulty copy of a single gene that codes for an enzyme that functions as one of the cell’s “recycling” machines. When it underperforms or fails, Fabry symptoms result. Instead of replacing the damaged enzyme, an alternative route called pharmacological chaperone (PC) therapy is currently in Phase III clinical trials for Fabry disease. It relies on using smaller, “chaperone” molecules to keep proteins on the right track toward proper folding. Garman says their use in Phase III clinical trials of PC therapy for Fabry disease could one day be far less expensive than the current standard, enzyme replacement therapy, and can be taken orally. "The interactions we looked at are exactly the things occurring in the clinical trial right now," Garman says. Further, "the same concept is now being applied to other protein-folding diseases such as Parkinson’s and Alzheimer’s disease. Many medical researchers are trying to keep proteins from misfolding by using small chaperone molecules. Our studies have definitely advanced the understanding of how to do that."

New tool for manufacturing 3-D shapes easily and cheaply to aid biomedical advances

UMass Amherst scientists have been inspired by nature’s ability to shape a petal to develop a new tool to manufacture three-dimensional shapes easily and cheaply, to aid advances in biomedicine, robotics and tunable micro-optics. Polymer Scientist Ryan Hayward, physicist Christian Santangelo, and their colleagues used polymer gel sheets and simple techniques from photolithography and printing to come up with a technique that may someday help biomedical researchers to direct cells cultured in a laboratory to grow into the correct shape to form a blood vessel or an organ. “We wanted to develop a strategy that would allow us to pattern growth with some of the same flexibility that nature does,” Hayward explains. Many plants create curves, tubes, and other shapes by varying growth in adjacent areas. “We now know a little more about how to go from a flat sheet of cells to a complex organism,” says Hayward.

Tiny particles deliver big for nanomedicine

Professor of Chemistry Vincent Rotello’s research on nanoparticles—tiny objects that have an array of unique physical properties—is having a huge impact on disease diagnostics and treatment. Rotello’s specialty is developing and testing Velcro-like coatings that allow nanoparticles to bind and interact variably with other molecules. One particularly innovative application of these coatings is a “chemical nose” that might someday transform cancer detection and treatment. “Our new method,” Rotello explains, "uses an array of sensors both to recognize known cancer types and to signal that other abnormal cells are present. Though it may have never before encountered a given particular type of abnormal cell, the chemical nose can tell us something isn’t right, like the ‘check engine’ light in your car.” In contrast to current detection methods, the sensor can perceive minute differences in concentrations of the cell-surface biomarkers that indicate cancer. Nanoparticles can also be used to attain greater control and accuracy in disease treatment.
Effective, accurate drug delivery is a significant challenge in treating cancer and other diseases. Treatment drugs, including chemotherapy, can affect healthy cells as well as diseased ones, causing unnecessary cell death and undesirable side effects. Current tumor treatments only kill cells on a tumor’s exterior, leaving open the threat of the tumor’s return. When attached to nanoparticles, however, drugs can be delivered inside of the tumor to completely destroy it.

UMass researchers unravel secrets of parasites' replication

A group of diseases that kill millions of people each year is unaffected by antibiotics, and some treatment is so harsh that the patient can’t survive it. They’re caused by parasites, and for decades researchers have searched for a “magic bullet” to kill them without harming the patient. Now, a team of UMass Amherst microbiology researchers has revealed new knowledge that could one day lead to an effective weapon for fighting parasitic diseases. Professor Michele Klingbeil, doctoral candidate Jeniffer Concepcion-Acevedo and colleagues recently reported the first detailed characterization of the way key proteins in a parasite organize to replicate its mitochondrial DNA. Understanding this coordination could enable pathways to launch new attacks on one of the parasites’ essential cell processes, Klingbeil says. According to Klingbeil, many parasites are not straightforward to treat because they are too similar to human cells. Antibiotics are ineffective, and so doctors often have to resort to the use of toxic chemicals. Klingbeil and her group are trying to find and exploit parasites’ weaknesses so that eventually there can be developed very selective, effective and acceptable treatments for parasitic diseases.

Heads up on Alzheimer’s

A new UMass Amherst study published in the American Journal of Alzheimer’s Disease and Other Dementias suggests that people at genetic risk for Alzheimer’s disease in midlife might already show subtle differences in how quickly they process information compared to those not at such risk. These differences might be associated with changes in brain volume, and could serve as markers to allow earlier detection and enhance chances for treatment. “Alzheimer’s is a progressive neurodegenerative disease in which neuropathology begins to accumulate decades before clinical symptoms are noticeable,” says lead researcher Rebecca Ready, an associate professor of psychology. Identifying these markers is important in order to maximize the opportunity for preventive interventions and treatment. “Our data suggest that investigators ought to consider the possibility of subtle changes in processing speed even before clinical symptoms of mild cognitive impairment or Alzheimer’s disease become apparent,” says Ready. She notes that the most valuable data about early Alzheimer’s will come from long-term studies among high-risk populations. “We hope to expand our current sample and follow them over time to determine which neuropsychological and brain volume measures are related to future cognitive decline,” says Ready.

Polymer model for human tissue relieves animal testing

Dr. Shelly Peyton creates testing platforms from polymers that have many key aspects of human tissues. When the artificial tissues are subject to real cancer cells, it’s possible to see how the disease develops and how cells move in those diseased tissues. By understanding the physical and chemical properties of both the diseased cells and the host environment, Peyton hopes to discover how and why cancer cells move to other parts of the body, a process called metastasis. She is also looking at how cells read and generate signals inside human tissues that trigger movements and change. One key to the process is creating the host materials. A chemical engineer, Peyton is collaborating with UMass Amherst polymer scientists to build the tissue platforms that meet different conditions. She and her associates have constructed a range of tissue models, including liver and cardiovascular tissues, both healthy and inflamed tissue, and breast tissue. These models also act as a substitute for using animals to study disease in the lab.

New tool developed to fight cell death-related disease

It has been estimated that more than half of all diseases for which we have no suitable treatment are related to malfunctions in the body’s way for programmed cell death, known as apoptosis. Apoptosis is the body’s way of getting rid of mutated, damaged, old, and other possibly harmful cells, and many researchers believe that mastering it could lead, for example, to a new cancer treatment. Now, Jeanne Hardy (Chemistry) and Kimberly Tremblay (Veterinary and Animal Sciences) along with members of their labs have discovered a way to control a particular enzyme of a group known as caspases that regulates programmed cell death. Using Green Fluorescent Protein (GFP), a visual marker that emits green light, scientists can watch film enzyme activities that control key processes inside a living organism. In almost all cancers, cancer cells turn apoptosis down which leads to unregulated abnormal cell division and tumor growth.

Encapsulation research delivers novel food technologies for a healthier future

Food science professors Eric Decker, Julian McClements and Yeonhwa Park are developing a technology to encapsulate fats in foods with dietary fiber to give consumers low-calorie versions that taste exactly like the real thing. Encapsulated fats can be used in blended foods, such as sauces, desserts, salad dressings and beverages. Fiber could also be used to encapsulate vitamins and antioxidants, enabling them to pass through the stomach and be released in the small intestine for absorption by the body. “Our goal is to keep the fat in food but stop it from being digested, by surrounding it with layers of dietary fiber,” says McClements. This process allows ingredients with proven health benefits but unpleasant taste, like Omega-3 fatty acids found in fish, to be included in a wider variety of foods. This team of researchers is also investigating how to customize the fiber layers to respond to different environments and testing whether this delivery system can also be used as a delivery for therapeutic drugs. “It should be possible to develop coatings that release drugs at specific sites within the human body,” says McClements.

UMass Amherst biochemists identify a crucial recognition tag in cellular 'garbage disposal'

Cells must routinely dispose of leftover or waste proteins by breaking them down, but the problem for biochemists studying this fundamental process is that molecules can be toxic garbage in one situation but essential for function in another, says UMass Amherst biochemist Peter Chien. Figuring out how bacteria and other cells accurately distinguish waste from useful molecules has been elusive, but his laboratory’s recent progress could offer medical researchers a
clue for controlling diseases such as bacterial infections and cancer cell growth. Chien and colleagues recently reported a two-part discovery, identifying new players in the protein-degrading system and how they work together at the molecular level. Chien says, “We study these proteins and how they interact not only because they’re involved in basic biological functions, but because they can help explain how bacteria go virulent, how they become infectious and how we may make them less virulent and less pathogenic. This could lead to developing new antibiotics to fight disease, for example.”

Understanding protein folding mistakes may lead to cures for neurodegenerative disease

Developing strategies for treatment and prevention of neurodegenerative diseases has presented major challenges to biomedical researchers because their causes are often unknown. When scientists better understand protein folding mistakes in cells, cures for neurodegenerative diseases such as Huntington’s and Parkinson’s are more likely to be found. Distinguished University Professor Lila Gierasch is a leading authority on how proteins fold and why they misfold. She specializes in how protein folding assistants in the cells called molecular chaperones optimize this process in living organisms. Results of her work have implications for a variety of diseases and disorders such as Alzheimer’s disease, cystic Fibrosis, transmissible spongiform encephalopathy (“mad cow disease”), and certain cancers. Gierasch and her Ph.D. student, Beena Krishnan, recently discovered new characteristics of proteins that shed light on protein misfolding. Gierasch describes how certain proteins use an unusual, spring-loaded loop mechanism to cripple their target enzymes as part of normal function. Their work reveals how a misfire, with no target present, causes the proteins to form damaging clumps, which lead to misfolding diseases such as emphysema and liver cirrhosis.

Minute motor holds answers to stem cell division

In basic research with far-reaching impact, biologists Wei-Lih Lee and Steven Markus have solved one of the fundamental questions in stem cell division: how dynein, the cell’s two-part, nanoscale “mitotic motor,” positions itself to direct the dividing process. The significance of this discovery has important implications. It should advance understanding of serious neurological disorders such as Alzheimer’s, ALS (Lou Gehrig’s disease) and human lissencephaly, a rare brain formation disorder resulting in a “smooth” brain without folds and grooves. In neurons, dynein’s major role is to carry waste products from the nerve terminal to the cell body. If this transport goes awry, neurons degenerate, leading to disease. “Our discovery solves a huge mystery about how dynein works during asymmetric cell divisions, such as those in stem cells,” Lee says. Asymmetric division in stem cells is specialized for generating different cell types that will develop into specific tissues such as skin, heart and kidney.

Discovery of new cell-regulating functions hold promise for cancer prevention

Dominique Alfandari and Helene Cousin, veterinary and animal sciences, and colleagues have identified unexpected and powerful cell-regulating functions in a protease known as ADAM 13, a discovery that holds promise for understanding tumor cell migration and the spread of cancer in the body. ADAM 13 regulates cell functions by cutting proteins to change their actions. In recent work, Alfandari and colleagues were the first to show that ADAM 13 has two parts dominated by different proteases, one active on a cell’s outer surface, the other inside the cytoplasm. Understanding that, they now want to learn more about how ADAM 13 cuts a protein called Cadherin-11 that has been shown to increase cancer cell invasion. The research is supported by the National Institutes of Health, which this summer awarded Alfandari and Cousin a $1.9 million grant to investigate craniofacial development in a frog model to better understand genetic control of cell migration. The work is expected to advance knowledge of how cancer cells migrate away from primary tumors to cause metastatic disease in new sites, among other processes.

Seeds to energy: using plant seed oils to create sustainable biofuels

One of the most promising avenues for reducing our national dependence on imported oil, lowering greenhouse gases and boosting domestic fuel production is biofuel from non-food plant seed oils. Recently, a UMass Amherst team initiated work on a $2 million project to develop Camelina, a non-food oil seed crop related to canola, to dramatically increase seed oil generation for processing into sustainable liquid transportation fuels. Plant oils can directly convert to biofuels with existing technologies, are compatible with current farm practices and are carbon neutral. As team leader and biochemist Danny Schnell says, “Our goals are to double the current maximum seed and fuel yield from Camelina while requiring less than 1 million acres to achieve the 100 million gallons per year target for commercial viability.” Camelina is an attractive candidate species, he adds, because it will grow in poor soil and not compete with food crops. It is also drought tolerant, has a short growing season and requires little fertilizer.

Microbial Electrosynthesis yields fuel and unleashes new applications

Microbiologist Derek Lovley is expanding on his landmark discovery of an electron-transporting bacterium, Geobacter, by introducing a groundbreaking energy conversion process called Microbial Electrosynthesis that harnesses natural geobacter functions. Lovley and his colleagues are demonstrating how the process can be used to convert carbon dioxide into fuel and other useful products. As part of a global effort to reduce carbon dioxide emissions, development of microbial processes could have monumental impacts. So far, the team has successfully engineered a strain of the bacterium that takes in carbon dioxide and water to produce butanol, a type of fuel. Microbial Electrosynthesis is vastly more efficient than existing technologies. Whereas most biomass technologies require large quantities of water and agricultural land in order to grow plants for fuel conversion, Microbial Electrosynthesis is a compact process that requires very little material and effort. The bacteria happily attach to an electrode and directly produce the fuel molecule, which they excrete from the cell naturally with no need for extraction or conversion. Lovley and the research team are now tasked by the Department of Energy to bring the model up to scale. “If it works, it’s really transformative. It changes the whole way you can go about making biofuels and commodities,” he says.
More efficient fuel cells means cleaner energy

Hydrogen fuel cells are an appealing source of clean energy because they have the potential to power anything that uses electricity—from computers and cell phones to cars and ships—without toxic emissions. Chemist Sankaran "Thai" Thayumanavan discovered a new material that improves the conductivity of protons, and is now working toward development of fuel cell membranes that stay chemically and mechanically stable much longer than current materials allow. The results are so promising that Thayumanavan received $40,000 from the Massachusetts Clean Energy Center to help demonstrate the technology's viability. "Our work should lead to a lighter, more efficient and sustainable source of clean power," says Thayumanavan.

Developing the next generation of solar cells

UMass Amherst chemists Dhandapani Venkataraman and Michael Barnes are delving into the complex chemistry challenges posed by photovoltaic energy. The two collaborators and their research team are steps away from realizing important new advances in polymer-based photovoltaic technology that have the potential to revolutionize solar cells. While silicon is currently the material of choice in solar energy due to its high energy conversion efficiency, it is expensive, inflexible and not "green." In contrast, organic photovoltaic cells made of synthetic polymers are greener and vastly less expensive. According to Barnes, the basic technology for organic photovoltaics has been in place for more than 20 years, but the materials aren't as efficient at power conversion as silicon. "The thrust is to make solar devices with power conversion efficiencies comparable to silicon at a tenth of the cost," says Barnes.

New method for producing everyday plastics

A team of UMass Amherst chemical engineers led by Paul Dauenhauer has discovered a new high-yield, inexpensive method of producing the key ingredient used to make plastic bottles from plant-based biomass. The process currently creates p-xylene, a key ingredient for making the chemical polyethylene terephthalate (PET), used in many products including beverage bottles, food packaging, synthetic fibers for fabric and even automotive parts. Dauenhauer says the new discovery shows that there is an efficient and renewable way to produce a chemical that has immediate and recognizable uses for consumers. While p-xylene is currently made from petroleum, other methods of producing renewable p-xylene are either expensive or inefficient due to low yields. Dauenhauer's discovery is a part of a larger, national effort by the national Catalysis Center for Energy Innovation (CCEI) to create breakthrough technologies for the production of biofuels and chemicals from biomass.

About the University of Massachusetts Amherst

UMass Amherst is one of the nation's top public research universities as measured by national and international rankings, academic citations, and research funding. The campus spends more than $180 million on research each year, demonstrating its contribution to the nation's position as a technological and economic leader. We work in conjunction with academic, government, and private partners to translate new knowledge and scientific discoveries into technical innovations and scholarly works that create opportunity for students, faculty and the public. To discuss R&D collaborations between your company and UMass Amherst researchers, contact the UMass Innovation Institute at umii@umass.edu.