Focusing on the Discoveries and Innovations Faculty and Students Are Making at *Florida Institute of Technology*

DISCOVERY

VOL. 12, ISSUE 1

Beating Cancer from the Inside Out

MESSAGE FROM THE PRESIDENT AND CHIEF EXECUTIVE OFFICER

Humankind progresses by discovering the new and building upon the known.

Both of these processes are at the heart of our mission here at Florida Tech, and the variety, depth and scholarship our faculty and students put into them are on brilliant display in the 2015 edition of our research magazine, Discovery.

As you'll see in the wonderful photos and compelling articles that follow, our scientists and researchers are tackling some of society's biggest challenges: cancer and Alzheimer's disease, global warming, space, our digital world and more.

It is a mix of nature and technology, of seascapes and outer space, of age-old ailments and challenges that could only arise in the modern era. Together, these myriad issues reflect the amazing variety of learning taking place within our classrooms and laboratories.

So we are both discovering the new and building upon the known here at Florida Tech, and I am delighted that with Discovery, you will experience and understand this for yourself, as well.

Sincerely yours,

A.J. Catanese, Ph.D., FAICP
President & Chief Executive Officer

MESSAGE FROM THE EXECUTIVE VICE PRESIDENT AND CHIEF OPERATING OFFICER

There is no substitute for learning by doing.

In my years in academia, and in my decades as an engineer and research scientist, I found that always to be the case. It certainly remains so today.

The research and discovery carried out in the classrooms and laboratories of Florida Tech—and brought to compelling life in the magazine you now hold in your hands—may be guided by our world-renowned faculty members, but the success and achievements laid forth here would often not be possible without the involvement of our students.

From undergraduates through our master's and doctoral candidates, students play a key role in our research here. Whether working in a lab or kayaking along the Indian River Lagoon, operating an unmanned aerial vehicle or monitoring vital signs during a clinical test, our students definitely learn by doing.

That's because Florid Tech understands the importance of taking learning beyond the classroom. After reading Discovery, I think you will, too.

Respectfully,

T. Dwayne McCay, Ph.D.
Executive Vice President & Chief Operating Officer

DISCOVERY
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Cover Photo: Michael Fenn, assistant professor of biomedical engineering at Florida Institute of Technology, with the university's custom-made Renishaw Raman micro-spectrometer, an essential tool for his cancer research.

Some of the vehicles and equipment used with Florida Tech's newest aviation minor.

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Minor Takes Off

Unmanned Aerial Systems program offers skills for aviation to come.

SPRING 2015 ISSUE

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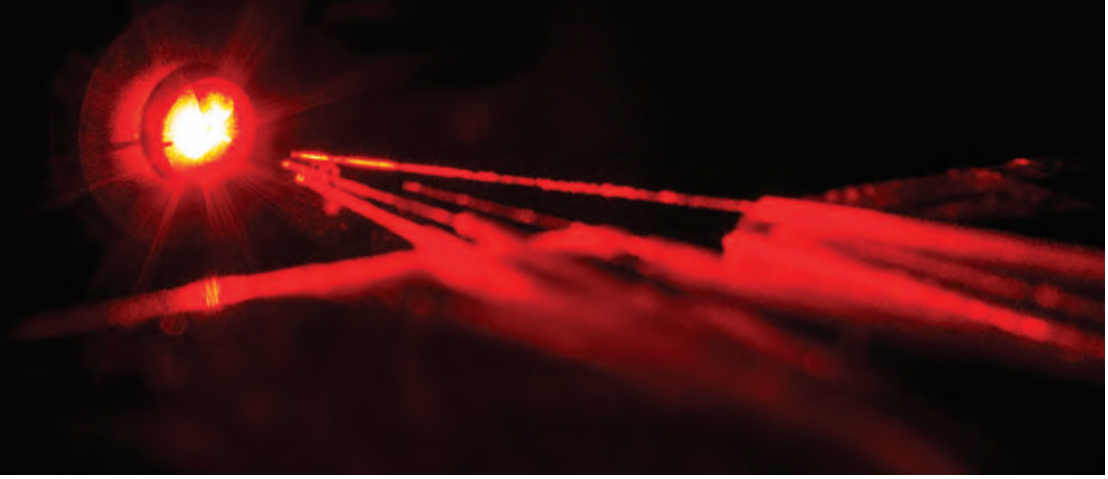
WE'RE LISTENING. *Please send any comments or suggestions to Adam Lowenstein, adam@fit.edu*



Optimizing Fiber Optics

If you have siblings or roommates, you probably know the telltale signs of reaching the bandwidth limits on your Internet connection: online gaming lags, streaming video won't load, frustration rises.

Total Internet traffic is increasingly globally, so slowdowns like this are afflicting apartments, houses and offices from Melbourne, Florida, to Mumbai to Milan. In fact, if traffic continues to increase at the pace it is rising now, we can expect to see a 10,000-fold increase in data traffic in the next 20 years, according to Syed Murshid, a professor in the department of electrical and computer engineering at Florida Tech.

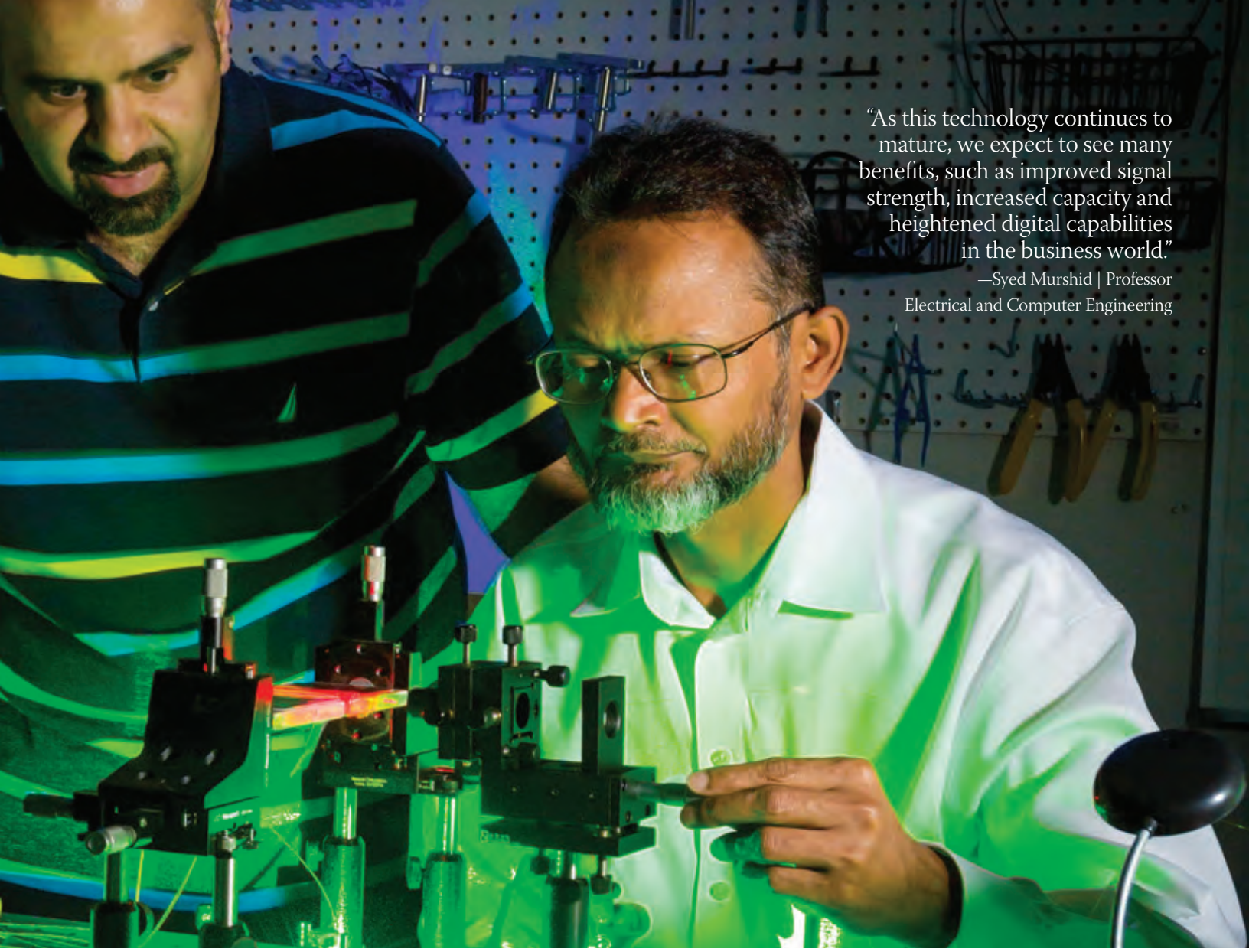
But Murshid isn't just monitoring that growth. He and his team of graduate students are responding to it with research and products that could drastically reduce, or even eliminate, these irritating slowdowns.

Because even with the fastest mode of data transfer available—fiber optics—the current infrastructure cannot support this kind of data increase. As the technology develops and demand rises, many buildings, including critical centers such as the Pentagon, are simply laying higher-speed fibers down because the cost of tearing into walls to remove the old ones is just too much.

This is a wasteful process that leaves a large amount of installed fibers unused. So Murshid and his team developed something called Spatial Domain Multiplexing that would allow these older fibers, as well as the new ones, to continue to be utilized as the demand for high-speed Internet increases.

Spatial Domain Multiplexing, or SDM, is a method within fiber optics that allows many channels of light to go through a fiber and, in the part of the process that earned Murshid and

Sending data in two directions—clockwise and counterclockwise—allows it to exist in the same circle at the same time, Florida Tech Professor Syed Murshid found. This orbital angular momentum allows for more data transmissions.



"As this technology continues to mature, we expect to see many benefits, such as improved signal strength, increased capacity and heightened digital capabilities in the business world."
—Syed Murshid | Professor
Electrical and Computer Engineering

Professor Syed Murshid, seated, works with his graduate student, Saud Alanzi, on an experimental demonstration involving his ground-breaking work in fiber optics.

his team a U.S. patent, be separated at the end. The channels are separated in a way that allows the capacity of current optical fibers to be multiplied.

The multiplexer device connects to the start and end of fibers and allows data to pass through in a series of concentric circles, rather than just one stream of data at a time, increasing the data rate by five times what unmodified fibers can do.

"As this technology continues to mature, we expect to see many benefits, such as improved signal strength, increased capacity and heightened digital capabilities in the business world," Murshid said.

As if that wasn't enough of a discovery, Murshid also proved the existence of something called orbital angular momentum in fiber optics. By sending some data streams in a clockwise motion and others in a counterclockwise motion, he has been able to show that these two sets of data can exist in the same circle at the same time, which further doubles the amount of data that can be transmitted.

All told, Murshid's invention, when implemented, could initially speed up existing Internet by tenfold, and even more in the future, meaning your next movie night and your roommate's gaming marathon could peacefully coexist.

Ashley Carnifax

Up in the Sky, Down on the Ground

Though unmanned aerial vehicles are, as the name suggests, lacking onboard pilots, these aircraft do not fly themselves.

But operating UAVs, which can range from lightweight quadcopters to Global Hawks weighing 15,000 pounds, is not like operating a remote-controlled helicopter from the hobby shop. Flying is part of the necessary skill set, to be sure, but so, too, is building, programming and modifying the vehicles—even planning missions.

All of those areas are taught in the Unmanned Aerial Systems program at Florida Tech, an 18-credit-hour minor that positions the Melbourne-based university among a handful of schools that understands the future of aviation, aeronautics and many other fields will involve unpiloted aerial vehicles—and people skilled in the ways to use them.

"It's an exciting place for the students to be, because they are getting into an industry on the ground floor," said Julie Moore, a major in the U.S. Air Force and assistant professor of aviation science at Florida Tech's College of Aeronautics, who is leading the UAS minor program.

And already that ground floor is crowded: scientific research, infrastructure inspection, firefighting, agricultural monitoring, law enforcement—all current or potential uses for unmanned aerial vehicles. There are geophysicists who use them to predict the location of mineral deposits and NOAA scientists who hunt hurricanes with UAVs.

And the list will only grow.

The World Unmanned Aerial Vehicle Systems, Market Profile and Forecast 2014 from Teal Group estimates that UAV spending worldwide will nearly double over the next decade, from $6.4 billion annually to $11.5 billion, with nearly $91 billion spent over that time.

Even before the launch of the minor program in fall 2014, Florida Tech faculty have been exploring the potential uses of unmanned aerial systems. For example, College of Engineering faculty members L. Daniel Otero and Paul Cosentino received a $250,000 grant from the Florida Department of Transportation to research the use of UAVs in inspecting bridges and tall lights, called high mast luminaries.

And Moore's students in the UAS minor are pursuing other areas as team projects. One will use an unmanned aerial system to simulate search and rescue efforts to determine how that method compares with on-foot searches. Another will investigate the efficacy of "geofencing" at airports, a technique that creates a GPS barrier meant to prevent UASs from entering particular airspace.

"There are so many applications even yet to be discovered, and the technology is only going to improve," Moore said. "People haven't really cracked the code on the best practices for different applications—what the challenges are, how to mitigate risk—and we're excited about exploring these areas and leading the way in this important research and discovery."

Adam Lowenstein

Leading the UAS minor program is Julie Moore, a major in the U.S. Air Force and assistant professor of aviation science at Florida Tech's College of Aeronautics.

"It's an exciting place for the students to be, because they are getting into an industry on the ground floor."

—Julie Moore | Assistant Professor of Aviation Science

Unmanned Aerial Systems lab assistant Dennis Dalli flies an unmanned aerial vehicle at the Center for Aeronautics and Innovation lab at Florida Tech. Through the goggles, he can see the UAV's camera feed.

Michael Fenn, right, assistant professor of biomedical engineering at Florida Tech, in the lab with Gengbo Liu. Fenn and his students are working on cutting-edge methods of cancer detection and therapy.

Search and Destroy

The relentlessness of cancer is renowned, and terrifying.

In 2015, more than 1.6 million new cases of cancer are expected to be diagnosed in the U.S., according to the American Cancer Society. And with nearly 590,000 Americans expected to die of cancer this year, the disease remains the second most common cause of death in America, accounting for nearly one of every four deaths.

Put another way, most of us have had cancer touch our lives in some way.

That includes Michael Fenn, one of several faculty members at Florida Tech who are focused on better ways to understand, detect and, someday, defeat cancer.

Fenn had his moment about seven years ago, in an operating room, as he observed a surgeon working on a tangerine-sized glioblastoma tumor, the most deadly type of brain tumor. At the time recently graduated with his undergraduate degree in chemistry and biochemistry, he asked this question: How could the surgeon differentiate the normal tissue from the tumor tissue?

"This silenced the normally bustling operating room, and his reply was something I will never forget," Fenn recalled. "He said, in a very calm, yet very frank and honest manner, 'Well, Mike, we try our best with all of this fancy equipment, but it's really still not much more than an educated guess.'"

That sparked Fenn's fascination with cancer research, and particularly with cancer detection. Now, as an assistant professor of biomedical engineering at Florida Tech and associate director of the university's Center for Medical Materials and Photonics, one of the

major objectives of his research is developing ways to both diagnose and treat cancers simultaneously, in real time. The hope is that these advances will enable doctors to do microscopic exams of living tissue inside the body during surgery and will help the accuracy of the diagnostic process in general.

Fenn is not alone in his quest. Others at Florida Tech, including Julia Grimwade and Alan Leonard, and Kunal Mitra, are bringing their own academic and scientific expertise to cancer-related challenges.

A CATALYST

Fenn himself was surprised — shocked, he said—by the surgeon's answer to his question. "This moment, ingrained in my brain almost as much as that of the patient in the operating room that morning, became my catalyst that sent me back to school in search of a better way to detect and diagnose cancer."

Fenn began working for a research group at the University of Florida Particle Engineering Research Center helping to develop novel nanoparticles that could provide a variety of imaging capabilities and highly specific cancer cell targeting, as well as simultaneous delivery of therapy. In other words, finding the cancer and then treating it.

That work has continued at Florida Tech, where Fenn is using a custom-made Raman spectroscopic imaging system and Surface-Enhanced Raman Spectroscopy (SERS), which utilizes cell-targeted gold nanoparticles—also developed in his lab—to greatly increase the Raman signal intensity and thus produce a significantly higher sensitivity and specificity.

These nanoparticles are amazing in their own right: They can be made to release a therapeutic payload via an optical drug delivery mechanism or be used for photothermal therapy, while simultaneously yielding real-time monitoring of the biochemical environment through continuous collection of data from the Raman system.

This technique, Fenn said, has the potential for use as a high-resolution, extremely sensitive in-situ histopathology platform; that is, it could be used to perform tissue analysis during surgical procedures, and thus be able to demarcate tumor borders from normal tissue and differentiate cancer subtypes with a high degree of specificity in real time.

No longer would that surgeon Fenn worked with years ago have to make an educated guess about cancer tissue and normal tissue.

"Such analysis capabilities afforded by the nanoprobes, and the ability to simultaneously then deliver treatment via optically activated drug release or heating of the nanoparticles by a laser light source, would dramatically enhance the way we detect and treat cancer," Fenn said.

Furthermore, doing so on a personalized level, by using antibodies attached to these nanoprobes that are specific to the cancer cells in a specific patient in tandem with Raman spectroscopy to detect and help determine the course of treatment for cancer patients, would be a major breakthrough and is one of the primary goals in Fenn's lab.

STUDYING GROWTH

Julia Grimwade and Alan Leonard have spent the past 25 years studying cell growth and division processes that are critical to understanding

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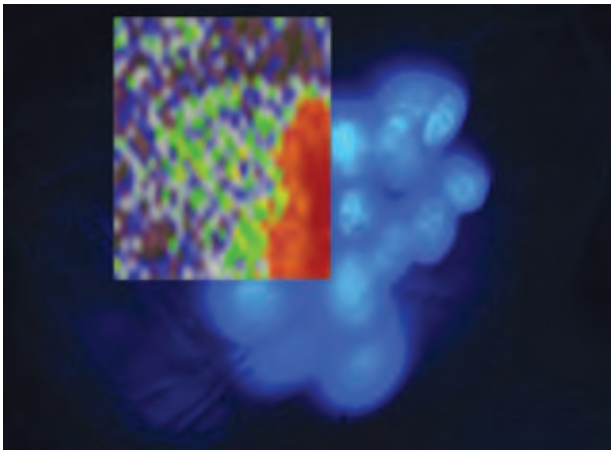
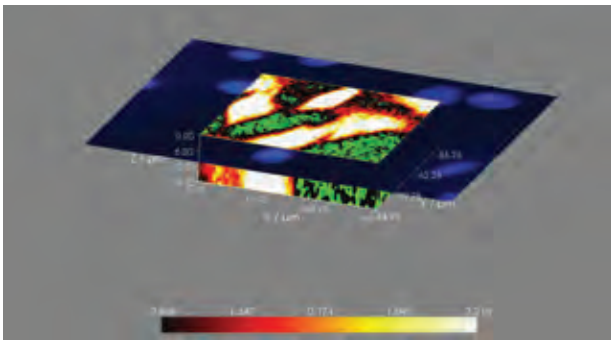
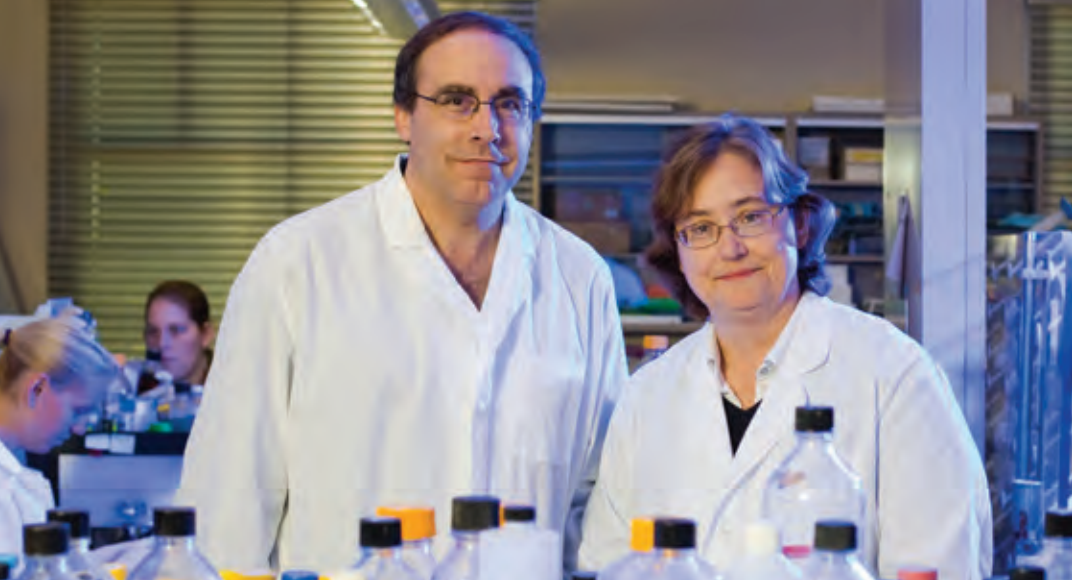


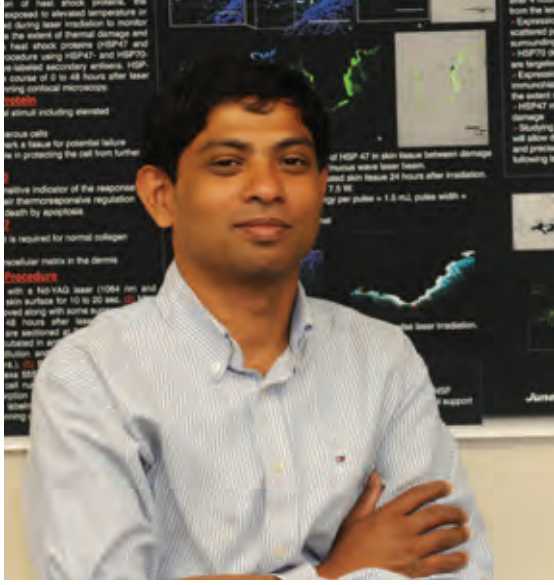


(top) This map shows a Raman/SERS spectral map overlaid on a fluorescence image of NIH3T3 fibroblast cells on a tissue engineering PCL polymer mesh treated with nanostars.

(bottom) A 3-D Raman spectral map of NIH3T3 fibroblast cells with overlay of fluorescence image.



Alan Leonard and Julia Grimwade



Kunal Mitra

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and, therefore, treating and even preventing diseases such as cancer and bacterial infections.

"All cells have to duplicate themselves in order to reproduce, and normally that's a really tightly controlled process," Grimwade, professor and chair, Premedical Biology Program in the department of biological sciences, said. "When it isn't tightly controlled in humans, we get things like cancer. In bacterial systems, if it isn't controlled and they infect us, then we get infectious diseases."

By determining the key stages in the DNA separation process, Grimwade and Leonard, a professor of biological sciences, are working to develop ways to inhibit cell duplication, which could prevent the growth and spread of a number of diseases.

In 2012, Grimwade and Leonard developed an easy method for placing mutations into DNA, simplifying the way they looked at possible protein-DNA reactions. Recently, they have used these mutations to characterize the stages of initiation—the process in which cells begin division—and to understand the role of specific proteins in this process. But as they've done these manipulations, they've found that other proteins are changing their behaviors to compensate.

Their more recent findings have confirmed that even in the simplest of systems, the beginning of chromosome replication is a very complicated process and is one best studied by asking simple questions and letting the answers lead to the next set of experiments.

LASER FOCUS

Kunal Mitra, a biomedical engineering professor at Florida Tech, focuses on the intersection between lasers and optics and biomedical engineering. He started by developing models for studying the way lasers interact with tissues. He said once he started looking for applications for this technology, cancer detection seemed like an obvious choice.

He holds a patent for an "Optical Tomography System using Short Pulse Laser for Early Cancer Diagnostics," which uses a short-pulse laser to transmit optical signals toward various tissue, which can then be reconstructed into 3-D images.

This noninvasive, quick procedure is ideal for early diagnosis of cancer.

"One of the goals of this research is using this system to detect cancer at early stages and then irradiate the tumor without causing thermal damage to surrounding healthy tissues, which occurs during such treatment," Mitra said. "This will be like a combined system which is challenging to build but unique in the field of cancer detection and treatment."

Mitra and his team have had great results using these technologies on animal models in the lab and hope to license it and develop a prototype system to use as a screening system for skin cancer detection.

Adam Lowenstein and Ashley Carnifax

A Murky Existence, in the Water and Out

Florida Tech, DEP, Brevard Zoo Join Forces to Better Understand Little-Known Turtle

"Pure turtle soup containing only genuine turtle meats," read one ad from the 1930s. "Special Homemade Snapper Soup 25¢," read another.

A century ago, turtle meat was more common in our kitchens. Often in soups, but found in a variety of dishes, turtle meat was a culinary trend that did more than get food on the table.

It also brought the diamondback terrapin to the edge of extinction.

Marc Virgilio, formerly with the Florida Department of Environmental Protection's Indian River Lagoon Aquatic Preserves program, holds a female diamondback terrapin.

The only turtle whose exclusive habitat is the brackish region of the Atlantic coast from Texas through Florida and into the grass flats north to Massachusetts, the diamondback terrapin had the unfortunate distinction of being among the most popular of the edible turtles.

At its peak, the meat from Malaclemys terrapin tequesta was worth more than gold. In addition to domestic consumption, these animals were also exported in huge numbers to Europe for the food market.

Since then, scientists, conservationists and researchers have worked to develop a better understanding of the seven subspecies of the diamondback terrapin. However, like the murky water these reptiles call home, one subspecies remains largely a mystery. It is the east-central Florida resident known as the Florida east coast diamondback terrapin.

"Efforts to save the species have led to studies in a variety of areas, but our own subspecies here in east-central Florida is probably the most poorly understood of any," said Michael Grace, associate dean of Florida Institute of Technology's College of Science and a professor of biological sciences.

Very little scientific work has been done on this subspecies to this point, Grace added.

"We don't know how many there are or where they live. We only know that they are apparently very uncommon."

The quest to fill in those gaps and better understand the key role these critters play in the Indian River Lagoon ecosystem led three powerful forces to unite: Florida Tech, the Brevard Zoo and the Florida Department of Environmental Protection (DEP).

Marc Virgilio, a former environmental specialist with DEP's Indian River Lagoon Aquatic Preserves program, and Amy Reaume, the zoo's conservation coordinator—both Florida Tech alumni, coincidentally—were joined by Grace and his students on kayak expeditions among the Thousand Islands, even as Virgilio and Reaume undertake efforts more specifically tied to their respective organizations.

They are among a host of community and state partners who have conducted field surveys and other research for the last several years to further our understanding of these small critters.

"There is a complete lack of data," said Reaume, who helped involve the community in monitoring Brevard County's terrapins by spearheading community reporting initiatives.

"The cause of diamondback terrapin declines are better known in other places. Once we understand their population dynamics here, we can help bring their population back to a healthy level again," she said.

The Florida Fish and Wildlife Commission, Virgilio noted, has designated the Florida east coast diamondback terrapin a "species of greatest conservation

This hatchling terrapin, named Tequesta, was found in a swimming pool and is now an outreach ambassador for wild terrapins at the Brevard Zoo.

From left, Florida Tech's Michael Grace, Rob Lara (rear) with Brevard Zoo, Sherri Emer with Florida Tech and Leann Winn, also with Brevard Zoo, with a female terrapin found on the survey along the Indian River Lagoon.

need," a testament to its declining population. The agency also acknowledges that terrapin status is unknown but declining in Florida.

Virgilio's exposure to terrapins goes back years to his time living in the northeast, where there were substantive terrapin restoration and management programs.

"But here in eastern Florida, we didn't even know where the populations were," he said. "But a new trail can be forged. There is a lot of potential."

On one kayak patrol last summer, the team found a young adult female diamondback terrapin and four terrapin skeletons. They found seven nests, as well, and used GPS coordinates to add their locations to a growing database.

It is this kind of information—on population and nesting habits, for example—that will allow scientists and environmental professionals to better understand, and therefore try to reverse, terrapin population declines.

"We must start by learning the basics so we can develop strategies for their conservation," Grace said. "As biologists, we're very interested in the turtle itself, but there are exciting, broader benefits to our work. This diminutive turtle is a great ambassador for the Indian River Lagoon. Its survival threatened, it's an important sentinel for the health and vitality of the lagoon, and its beauty is inspirational to all who meet the little diamondback terrapin."

Adam Lowenstein

Want To Get Involved?

Visit https://brevardzoo.org/conservation/local to find a section on the Florida east coast diamondback terrapin conservation program, including the "Have You Seen Me?" flier with the latest information on the best way to report terrapin sightings. Citizen spotters are also encouraged to enter sightings through the form found at www.jotform.us/brevardzoo/IRLterrapin.

Head's Up

At Florida Tech's Human-Centered Design Institute, technology is abundant.

Flight simulators fill one room. In another, an elegant MakerBot 3-D printer sits ready to make something, anything with its bright plastic filament.

And here is a curved band of polished metal with a few plastic parts and two thin, metal strands extending down from the middle. The most mundane looking of all the gadgets at the institute, it is potentially the most disruptive.

But it's not necessarily about the technology embodied in Google Glass, which is a trademark of Google Inc. It's about incorporating and accepting that technology and allowing it into what we do, how we work, how we live.

That's where Ondrej Doule comes in.

Doule, an assistant professor at the institute, known as HCDi, would say Google Glass has a high maturity of technology but a low maturity of practice. Equalizing that balance is why in October NASA's Space Technology Mission Directorate agreed to fund a two-year proposal that involves Kennedy Space Center, Doule and other partners who will explore how wearable technology and heads-up displays like Google Glass could eventually be a part of the work done by spaceport technicians and even astronauts.

Wearing a helmet equipped with a system embedded in the visor, astronauts on a spacewalk could see updated instructions for fixing an unexpected problem scrolled before their eyes, Doule said, even as the readout allows them to monitor temperature, vital signs or other mission-critical information.

Called Integrated Display and Environmental Awareness System, or IDEAS, the project's goal is, according to NASA, "to enhance real-time operations by providing various means of communication and augmented reality data to field engineers here on Earth and in space."

In addition to NASA's Kennedy Space Center and Florida Tech, other partners are center contractor Abacus Technology and Orlando-based Purple Rock Scissors.

KSC's David Miranda, the project lead, said the team is a strong one.

"These partners bring a mix of skills that will involve innovative and agile approaches, ensuring that a technology is developed with the user in mind," he said.

Though a seemingly simple premise, developing technology with the user in mind is difficult to achieve.

Doule is part of the project's usability team. He supports critical tasks related to user needs and their transformation into a relevant, innovative system that is wearable.

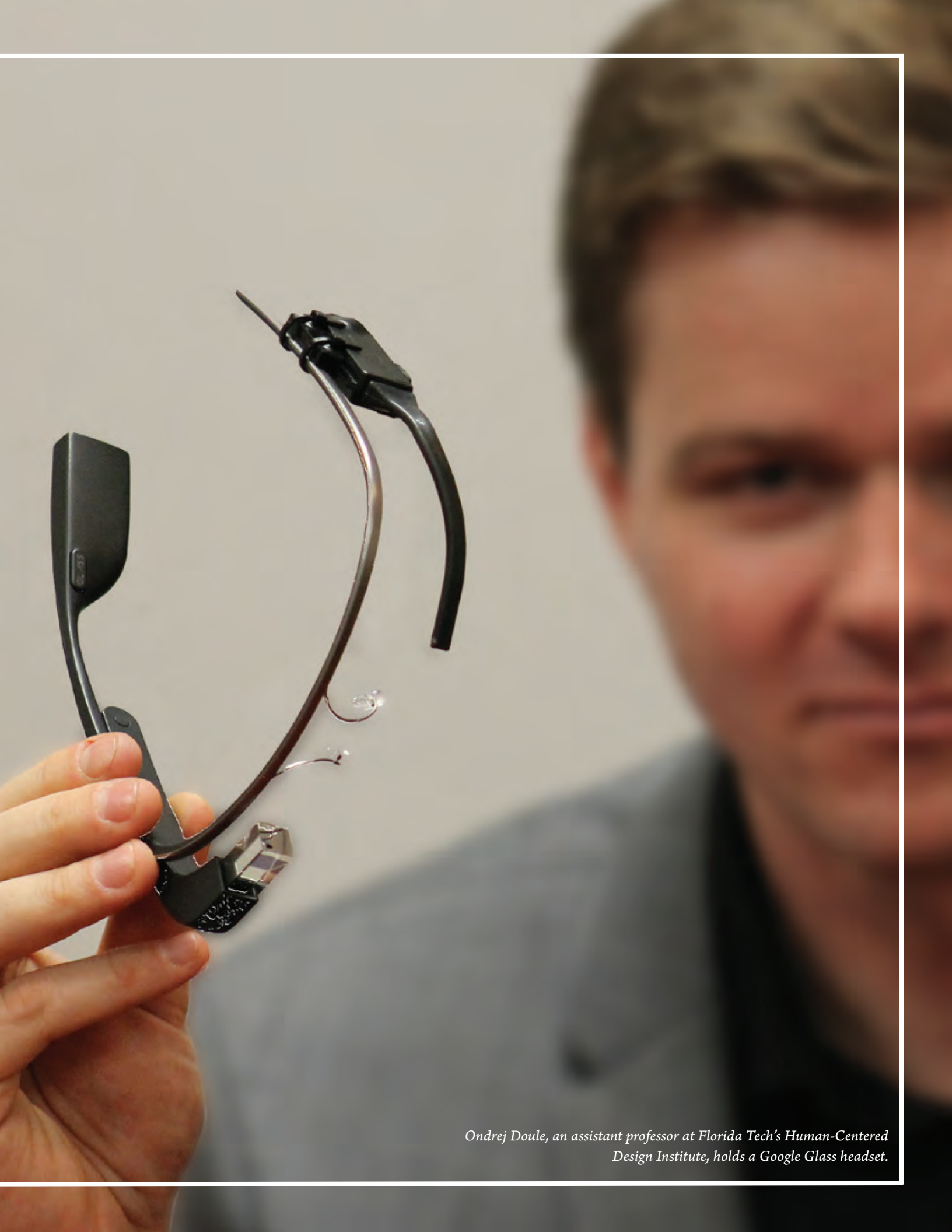
"There are a high number of users this system has to accommodate and rapidly evolving technology," Doule said. "So our tasks also include broad research into technology, interviews with future users, system architecture definitions, generation of operational scenarios and identification of common and special features of the IDEAS system."

Everyone on the IDEAS project produces design requirement documents in real time to allow the end product to evolve. Already they have created five concept versions of the IDEAS product. Soon to come will be 3-D-printed concepts.

"That is our challenge," Doule said. "How we can use this very sophisticated, miniaturized technology? How we can leverage it?"

The answers could change the way people work.

Adam Lowenstein



Ondrej Doule, an assistant professor at Florida Tech's Human-Centered Design Institute, holds a Google Glass headset.

Coral Reefs and Warming Oceans

Providers of critical marine ecosystems for millennia, coral reefs are disappearing at alarming rates.

"We are a step closer to predicting where diseases are occurring because now we know why they are occurring."

Robert van Woesik | Professor | Biological Sciences

Two studies led by Florida Tech biology professor Robert van Woesik and published this year found that rising ocean temperatures are hastening that decline, but encouragingly, also discovered that pockets of cooler water may allow reef-building corals to survive well into the future.

The first study, published in the February issue of *Nature Climate Change*, connected the warming Atlantic Ocean with the dramatic decline of the iconic elkhorn and staghorn corals of the Caribbean.

The results of the study also suggest that limiting the rate of ocean warming, which would require curbing greenhouse gas emissions, could support the recovery of these critical reef-building corals.

Van Woesik and Florida Tech Ph.D. student Carly Randall, pictured left, studied the relationship between ocean temperatures and white-band disease, a widespread coral disease that has afflicted elkhorn and staghorn corals for decades.

Randall and van Woesik wanted to know if changes in ocean temperatures associated with climate change have contributed to the spread of the disease throughout the Caribbean. The answer, according to their research, was that the rising temperatures did affect the disease's spread.

"Our data show that climate change has helped drive down staghorn and elkhorn corals by boosting white-band disease," Randall said. "We still don't know if the disease is caused by a marine microbe, but now we do know that changes in the environment contributed to the problem."

The study also found that the disease is more common in places where the waters have been warming most rapidly and where the waters stay unusually warm in the winter season. The scientists think that without a cooling-off period, the effects of the hot summers linger, and the disease is more likely to worsen.

Researchers have struggled to identify the causes of the disease. The results of this study are a critical step forward in our understanding of white-band disease, van Woesik said.

"The discipline has been stumped for more than 20 years because the environment played a larger role than we first anticipated," van Woesik said. "We are a step closer to predicting where diseases are occurring because now we know why they are occurring."

Another Florida Tech study involving corals answered another important question: Could corals survive and even grow in certain ocean refuges?

Working with Ph.D. student Chris Cacciapaglia, van Woesik reported in the March issue of *Global Change Biology* that in some pockets of cooler ocean water, corals were surviving.

"The idea was to identify regions that will experience little temperature change by the year 2100 —refuges where coral survival is most likely," Cacciapaglia said.

Although their models show significant loss of corals as the oceans warm, they also highlight 12 areas —five in the Indian Ocean and seven in the Pacific— where corals are likely to survive at least until 2100.

"These refuges should be essential for coral survival into the future, and these locations deserve protection," said van Woesik.

Adam Lowenstein

The mask allows subjects to breathe various combinations of oxygen and carbon dioxide as Mitra and his team collect data from sensors to evaluate the effects of concussion that cause dysfunctional control of cerebral blood flow.

Graduate student Stephanie Miller, left, works on the Non-Invasive Cerebrovascular Regulation Assessment project with graduate student Likitha Somasekhar, seated.

A Deeper Understanding of Concussions

Likitha Somasekhar, a biomedical engineering master's student at Florida Institute of Technology, sat in an oversized office chair, looking up from behind a modified scuba mask as she inhaled an air mixture containing 3 to 5 percent carbon dioxide.

She nodded, indicating she was doing well, and continued to look around the room, breathing slowly and steadily.

Somasekhar is one of 26 students participating in the early stages of an experiment being conducted by Florida Tech biomedial engineering professor Kunal Mitra.

Mitra, alongside neurosurgeon Isabelle Richmond and John Borgos, president of a small medical device company called Brain Check Medical, received more than $90,000 from the National Science Foundation to develop a method for testing one of the major effects of a concussion—alteration of blood flow to the brain.

Called Non-invasive Cerebrovascular Regulation Assessment, the research may help develop sensors and algorithms that could serve as tools for initial detection, assessment, monitoring and rehabilitation of individuals with concussions.

One of the challenges in studying the effects of a concussion is finding suitable subjects to observe—researchers can't just take measurements from someone, induce a concussion and measure the difference. So, instead, Mitra and his team developed a system using a modified scuba mask, with parts created using the 3-D printers available in the Electronic Support Lab at Florida Tech. The mask allows subjects to breathe various combinations of oxygen and carbon dioxide as Mitra and his team collect data from sensors to evaluate the effects of concussion that cause dysfunctional control of cerebral blood flow. During the experiment, Richmond oversees the vital signs such as blood pressure, heart rate, pulse and other important measurements to ensure the students participating are not experiencing any undesirable symptoms.

Carbon dioxide is used because it is a highly diffusible substance that rapidly crosses the blood brain barrier and causes a striking increase in cerebral blood flow in human subjects administered that 3-5 percent CO_2 mixture.

The changes induced by short-term carbon dioxide administration—typically 30 minutes or less—are rapidly reversible with return to breathing ambient air, Mitra said, adding that the use of the air mixture is essential for the research. The team will next develop an approach for testing in an outpatient environment.

"In order to test our hypothesis that alterations in carbon dioxide reactivity are a good marker for post-concussive effects, we will need to develop parameters which will allow evaluation of this threshold in an outpatient setting which will not subject the patients to an uncomfortable or clinically intolerable experience."

The researchers hope that by comparing the data from before and after the carbon dioxide, they'll have some insight into how the body copes with this decrease in oxygen, giving them more information about the long-term effects of concussions and similar brain injuries in post-concussive individuals with impaired cerebral blood flow control.

In addition to the scientific contributions, the project is also providing a hands-on research experience for many students. In addition to the students who are participating as subjects, Mitra enlisted the help of Stephanie Miller, a mechanical engineering Ph.D. student, to assist in the data collection and analysis.

"I can't even sum up how much this has enhanced my learning because it brings together the aspects of clinical trials, commercial testing and sensor development," Miller said. "It helps me get the full flavor of what it takes to commercialize a product and do the research to get that done."

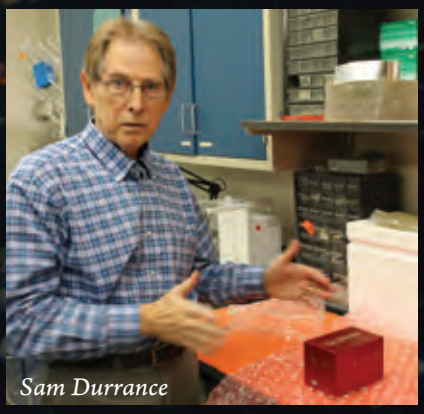
Ashley Carnifax

The View from Above

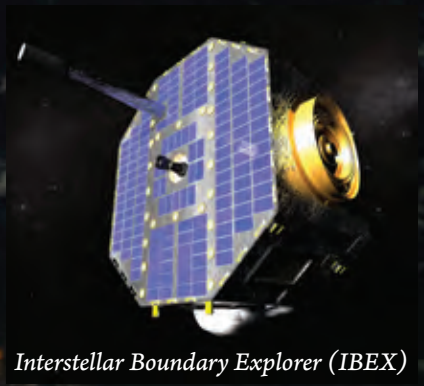
From growing protein fibers on the International Space Station in order to better understand Alzheimer's disease to studying the sun's interaction with the far reaches of our solar system to developing a camera to improve space-based observations of other planets and stars, Florida Tech faculty continue to strengthen the university's heritage as a leader in astronomical research.

Here's a look at several recent projects.

PROTEIN POWER. Daniel Kirk, professor of aerospace engineering and associate dean for research in the College of Engineering; Sam Durrance, professor of physics and space sciences; and Hector Gutierrez, professor of mechanical engineering, have undertaken a project entitled, "Self-Assembly in Biology and the Origin of Life," or SABOL, which utilizes the weightless environment afforded by the International Space Station to study fundamental biological processes such as protein self-assembly.



Sam Durrance



Interstellar Boundary Explorer (IBEX)

After 25 days in the ISS, the experiment was returned to Florida Tech this spring. Though the bulk of the analysis remains to be done, Durrance reported that protein fibers did grow during SABOL's time in space. Those will be compared with a ground control unit that was conducted in a nearly identical manner to the ISS-based experiment.

The results of this work will help define self-organizing processes that are fundamental to the origins of life, and apply to the understanding and treatment of neurodegenerative disorders including Alzheimer's disease.

LOOKING OUTWARD. Florida Tech physics and space sciences research professor Konstantin Gamayunov has been studying the outer heliosheath, the region outside of the solar system where the sun's influence ends, thanks to a three-year, $310,000 grant from NASA.

The project, "Global system-based approach to test a mechanism of the IBEX ribbon formation in the outer heliosheath" is the continuation of research by project leader Gamayunov and collaborator Ming Zhang, Florida Tech professor of physics and space sciences, as well as researchers from the University of Alabama in Huntsville and the University of New Hampshire.

Their work analyzes particles called energetic neutral atoms (ENA). These particles are visible using a small satellite called the Interstellar Boundary Explorer (IBEX) that NASA launched in 2008. The goal of the project is to investigate the mechanism of ENA formation; they are believed to form when solar wind protons and interstellar gases collide.

According to Daniel Batcheldor, associate professor and head of Florida Tech's physics and space sciences department, "Just as the Earth's magnetic field protects us from the damaging effects of some of the sun's radiation and particles, the large-scale effects of the sun itself reach out past the boundaries of our solar system and protect us from the potentially harmful environment of our own galaxy. Determining precisely how the sun interacts with the rest of the galaxy could help us understand another important role the sun plays in allowing life to prosper on our planet.

DUST BUSTER. Hamid Hefazi, a professor and head of Florida Tech's mechanical and aerospace engineering department, was awarded nearly $25,000 from the Florida Space Research Program for his project, "Discrete Element Modeling of Regolith During Lunar Landing," which focuses on the interaction of supersonic rocket plumes with regolith, a layer of loose material covering the surface of terrestrial planets.

When a spacecraft takes off or lands on the surface of a planet or another object in space, rocks and particles can fly off the surface and travel long distances, obscuring crew visibility and creating a hazard for the spacecraft and any nearby objects. Along with a graduate student, Hefazi will work to establish a scientific methodology for simulating and predicting these interactions to help avoid dangerous visual and physical hazards in future space missions.

PICTURE PERFECT. Batcheldor, the associate professor and department head, is leading a project that will send a special camera up to the ISS later this year, where it will be installed outside the station for up to 90 days for testing.

The camera is designed to handle extreme contrast ratios where the brightness ratio between a bright and faint object is 1 billion, something akin to trying to spot a candle next to the beacon of a lighthouse. Being able to record such images is important for making observations of planets around other stars and for a range of remote sensing applications.

Durrance and Zoran Ninkov, professor of imaging science at Rochester Institute of Technology, are joining Batcheldor on the project, which was selected for funding by the Center for the Advancement of Science in Space (CASIS).

The test, to be undertaken next year, involves building an extreme contrast ratio camera into an 8-inch-long box that will be installed in a cabinet with other research projects. The cabinet will then be placed outside the space station for 90 days while researchers run their tests, which will include monitoring how the space environment affects aspects of the camera's highly specialized sensor.

Adam Lowenstein

Research in Brief

Florida Tech has a long-standing history of conducting cutting-edge research in a wide variety of disciplines. The level of funded research has steadily risen over the years, and as such has served to solidify Florida Tech's reputation as a world-class university.

College of Aeronautics Tabbed for PEGASAS

The College of Aeronautics was selected to be part of PEGASAS, the Partnership to Enhance General Aviation Safety, Accessibility and Sustainability. The 10-year partnership brings together the top universities in aviation research to help the Federal Aviation Administration improve the field. Through PEGASAS, member schools are assigned FAA-selected research projects that best fit with the schools' research strengths. Florida Tech has been assigned to work on two projects: Angle of Attack Equipment for General Aviation Operations, which looks at installing an instrument in the cockpit that will provide information to pilots about a specific aircraft's angle of attack; and Rotorcraft Flight Data Monitoring, which focuses on helicopters and the study of Flight Data Management systems to increase safety in the rotorcraft community.

Patent Awarded to Ocean Engineering Faculty, Former Students

Ocean engineering professor Stephen Wood and two recent graduates, Kelly Dunn and Deric Hausmann, were awarded a patent for their work on the GECCO, a wave energy harnessing device that floats on the ocean's surface and converts energy from ocean waves into easily used power. The design of the device also allows it to be used to convert salt water into fresh water via reverse osmosis, making it a great resource for impoverished countries and disaster zones.

Homeland Security Awards $730K Grant to Improve Cyber Infrastructure Defense

Associate professor Marco Carvalho was awarded a $730,000, two-year contract by the Department of Homeland Security, Science and Technology Directorate to design a cyber-defense framework that will allow multiple organizations in both civilian and government sectors unprecedented levels of coordination in their efforts to protect the nation's cyber infrastructure. Carvalho, who works in Florida Tech's department of computer science and cybersecurity, is the executive director of the school's Harris Institute for Assured Information. He is leading the research effort with his team at the institute and will support the design of new techniques and algorithms for the monitoring, control and coordination of cyber sensors and defenses across multiple domains and across administrative boundaries. The proposed federated command and control infrastructure will enable coordinated detection and response to cyber events across different organizations, a powerful and important capability in efforts to improve the defense of the national cyber infrastructure.

Upward Lighting Captured by FIT Cameras

A team of Florida Tech researchers led by associate professor Ningyu Liu captured rare video of hard-to-predict upward-moving lightning discharges, allowing for the study of this phenomenon in a way that has not been previously possible. The study and accompanying video, which were published in the January 2015 edition of *Nature Communications*, focus on the electrical activities of Tropical Depression Dorian in August 2013, which featured seven upward-moving lightning events, each having unique optical and radio signatures. One of the key findings from these new observations was that all seven events originated in the same thundercloud region, suggesting that these different kinds of events are generated by the same physical mechanism. "This latest observation represents yet another exciting discovery that will help us better understand the properties of lightning in all of its diverse forms," said Hamid Rassoul, dean of the College of Science and a researcher on the project.

Research Blowing in the Wind

Marine and environmental systems associate professor Steven Lazarus and research associate Michael Splitt, joined by several graduate students and members of the 45th Weather Squadron, have spent the last seven years evaluating the National Hurricane Center's Tropical Cyclone Wind Probability Forecast Product and developing a tool that helps decision-makers better understand and evaluate weather risks. Understanding the meaning behind weather probabilities and being able to interpret and react to them could help emergency workers and other decision makers, such as the 45th Weather Squadron, better prepare for dangerous weather. That, in turn, could save lives. The team received a series of three grants from NASA to complete this research totaling approximately $56,500 over four years. The grants were used primarily to support three graduate students, Jaclyn Shafer '08, Denis Botambekov '11 and Sarah Collins '13, all of whom completed their master's theses as part of the larger research project. The results of this research are being published in an upcoming issue of *Weather and Forecasting*, a journal distributed by the American Meteorological Society.

Video of upward lightning captured by Florida Tech cameras during August 2013's Tropical Depression Dorian.

Tracking Glacial Melt from Afar

Mathematics assistant professor Nezamoddin Kachouie and several collaborators have developed a method for tracking and estimating mountain glacier change via satellite images. Ground-based measurements of the terminus point—the point where the glacier meets water or ground—are available for some glaciers. However, ground measurement requires scientists to physically travel to mountain glaciers, a near impossibility in some instances with many mountain glaciers inaccessible or extremely difficult to visit. That limits the data to which researchers have access. As part of their research, which was published in the March 2015 issue of *IEEE Transactions on Geoscience and Remote Sensing*, Kachouie and his collaborators developed a suite of techniques that allows researchers to locate terminus points on Landsat satellite images of mountain glaciers and track the changes over time by comparing these points and evaluating them using a variety of mathematical and statistical methods, which they also developed.

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DISCOVERY

David Moreno, thermal spray engineer, operates robotic equipment in Florida Tech's Thermal Spray Laboratory.

THERMAL SPRAY LABORATORY

If a key component of a turbine engine fails, the results can range from inconvenient to disastrous. A team of researchers is investigating how critical engine parts break down at high temperatures and what kinds of coatings make those parts safer and more efficient. Part of the National Center for Hydrogen Research, the Thermal Spray Laboratory and the High Heat Flux Test Laboratory create a specialized environment to apply and test various coatings in extreme heat. "There aren't many sites in the country that provide these services in one location," said Mary Helen McCay, director. For more information, visit research.fit.edu/nhc.

DISCOVERY is printed on Sustainable Forestry Initiative (SFI)® certified paper.

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