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COLLEGE OF COMPUTER, MATHEMATICAL, AND NATURAL SCIENCES

ODYSSEY

GAME CHANGER

Brendan Iribe Continues To Show His Vision

ODYSSEY

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Odyssey is published twice a year for alumni, friends, faculty, staff and students of the College of Computer, Mathematical, and Natural Sciences. Your comments and feedback are welcome. Please send them to abbyr@umd.edu.

Dear Friends,

This fall marked the fourth anniversary of the College of Computer, Mathematical, and Natural Sciences. Coinciding with this anniversary, we announced the largest single gift in University of Maryland history. Brendan Iribe, former student and co-founder and CEO of Oculus VR, donated $31 million to the university. Brendan's business partner and computer science alumnus Michael Antonov, and Brendan's mother, Elizabeth, also contributed generous gifts of $4 million and $3 million, respectively.

These gifts will support construction of a new computer science building on campus, create scholarships and endow professorships. The new Brendan Iribe Center for Computer Science and Innovation will advance research in virtual reality, augmented reality, computer vision, robotics and immersive science at the University of Maryland. The facility will feature state-of-the-art maker spaces with access to new equipment and resources that will enable students and faculty to bring their ideas to life. You can read more about Brendan, these wonderful gifts and the Iribe Center beginning on page 16.

We also celebrated the launch of our third quantum science research center in October. Called the Joint Center for Quantum Information and Computer Science, the center expands our long-established partnership with the National Institute of Standards and Technology. Center researchers aim to understand how quantum systems can be effectively used to store, transport and process information. This understanding will be critical for quantum computers, which could be immensely faster than any existing computer at solving certain problems. The race is on to build the first quantum computer —and, right now, a device in the basement of the Computer and Space Sciences building is leading the field. You can read more on page 4 about this device and other quantum computing strategies our researchers are exploring.

Finally, we invite you to join us on March 10, 2015, for a mathematics conference to honor our dear colleague and leader, William E. "Brit" Kirwan. Chancellor of the University System of Maryland for the past 12 years, he is retiring after more than 50 years in higher education. Brit joined UMD as an assistant mathematics professor in 1964 and worked his way up to president, a role he held from 1988 to 1998. The conference will feature lectures on mathematics and education by Brit's former colleagues, UMD alumni and renowned mathematicians from across the country.

As always, we thank you—our alumni and friends—for your collective support, which moves us ahead and ensures that our college remains at the forefront of research and education.

Jayanth Banavar
Dean
College of Computer, Mathematical, and Natural Sciences

Photo by John T. Consoli

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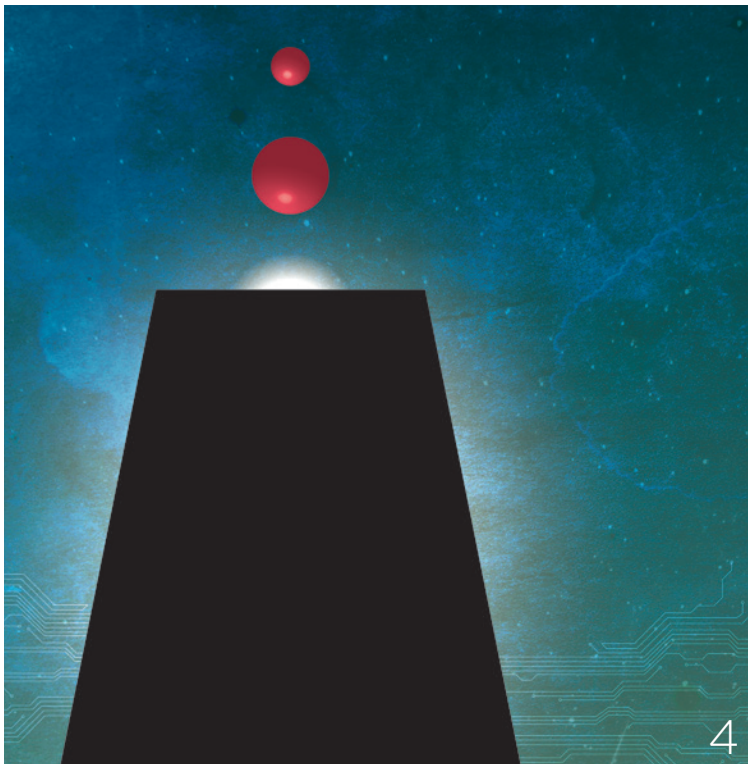
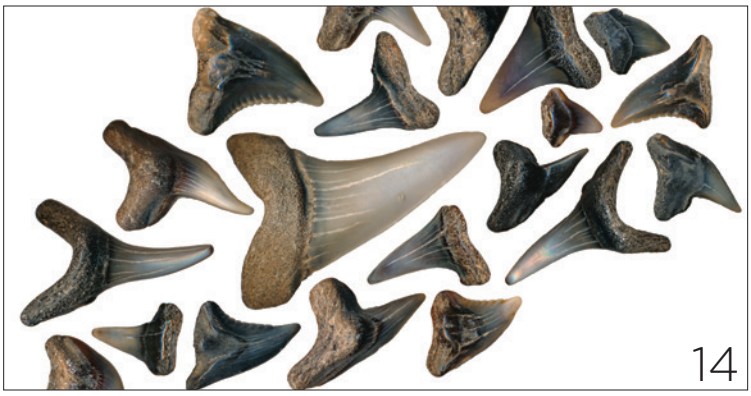




ON THE COVER

BRENDAN IRIBE CO-FOUNDED THE VIRTUAL REALITY COMPANY OCULUS VR AND THEN SOLD IT TO FACEBOOK FOR $2 BILLION THIS PAST JULY. IN SEPTEMBER, IRIBE PLEDGED THE LARGEST SINGLE GIFT IN UNIVERSITY OF MARYLAND HISTORY—$31 MILLION—TO SUPPORT CONSTRUCTION OF A NEW COMPUTER SCIENCE BUILDING AND SCHOLARSHIPS.
Photo by John T. Consoli

Illustrations by Loretta Kuo / Iribe photo by Mike Morgan

2015:
a quantum odyssey

THE RACE IS ON TO BUILD THE FIRST QUANTUM COMPUTER—AND UNIVERSITY OF MARYLAND SCIENTISTS ARE LEADING THE WAY.

By Heather Dewar

Illustrations by Loretta Kuo

There is an apparition in the basement of the university's Computer and Space Sciences building.

It is not an apparition in the supernatural sense, or in the Harry Potter novels' sense of teleportation, though that notion is not so far from reality. Rather, the apparition is the unexpected appearance of a transformational invention with the power to change the world.

Many scientists think society is on the brink of a second information age, thanks to a new field known as quantum information, sprung from the marriage of quantum physics and theoretical mathematics. The invention that could usher in this second information age is a quantum computer.

"Quantum computers will be able to solve some problems dramatically faster than today's computers and solve difficult problems that are not solvable today," says Jayanth Banavar, dean of the University of Maryland's College of Computer, Mathematical, and Natural Sciences and a physics professor. "They will change our lives in ways that we cannot even imagine."

"A quantum computer is the holy grail of quantum science," adds UMD Physics Professor Steve Rolston, who co-directs the Joint Quantum Institute (JQI), a research partnership between UMD and the National Institute of Standards and Technology, with the support and participation of the Laboratory for Physical Sciences.

Because of the quantum computer's potential to alter the field dramatically, scientists are researching every possible application of quantum information—communication networks that cannot be tapped; small, powerful sensors with more uses than we can currently guess; and materials with strange and potentially useful properties. The researchers' goal is to understand how quantum mechanics can store, process and transmit information faster, better and more securely than today's technology.

Quantum possibilities

The race is on to build the first quantum computer. Right now, the device in the basement of the Computer and Space Sciences building is a leader in the field. This futuristic machine is fundamentally different than any computer on the market today.

A typical computer stores information in bits—individual digits, all of them either 0s or 1s. A laptop with one gigabyte of memory can store 8 billion 0s or 1s. A computer scientist would describe that memory as 8×10^9 bits. But a quantum computer takes advantage of the unseen properties of what physicists call "the quantum realm"—typically, the world of atoms and subatomic particles, things too small to be seen with the naked eye. In this world, a quantum bit—or qubit—can be a 0, a 1 or both at the same time. That means a single qubit could give a quantum computer's operating system the capacity to do two calculations at once. And unlike a laptop, which adds computing power in a linear way as more bits are added, a quantum computer grows exponentially. A program using two qubits can do four calculations at once (2^2), one using three qubits can do eight (2^3) and so on. A quantum computer with 300 qubits could represent vastly more information than a conventional computer, 2^{300} or about 10^{90} numbers.

"That is more than the number of particles in the universe," says Christopher Monroe, Bice Zorn Professor of Physics and a JQI fellow (a title given to research scientists on the institute's permanent staff). "A quantum computer that big could deal with massive amounts of data in a way nothing else can."

Monroe intends to build that quantum computer. The apparition in the basement of the Computer and Space Sciences building is his device—an array of lasers, lenses, mirrors, optical cables, cameras and steel boxes laid out on a table the size of a two-car garage door. At its heart is a vacuum chamber with 20 electrically charged ytterbium atoms held in a bowl made of electromagnetic fields and kept in a quantum state of multiple possibilities.

ION TRAPPER: CHRIS MONROE

MONROE'S ION TRAP IS A FRACTION OF A MILLIMETER IN SIZE. FOUR GOLD ELECTRODES IN THE SHAPE OF RAZOR BLADES GUIDE ELECTROMAGNETIC FIELDS INTO THE CENTER TO FORM AN INVISIBLE BUCKET THAT HOLDS ATOMIC IONS. THE POSITIVELY CHARGED IONS LINE UP AND PUSH AGAINST EACH OTHER. IN THIS POSITION, THE SYSTEM BEHAVES AS A SMALL QUANTUM COMPUTER, WITH EACH ATOM ACTING AS AN INDIVIDUAL QUANTUM MEMORY ELEMENT.

At 20 qubits, Monroe's creation is among the largest quantum computing devices in the world. (A company in Canada has built a 512-bit machine, but experts question whether it is a true quantum computer, and test results are contradictory.) Monroe, who has been working in the quantum science field for 20 years, plans to build a 50-qubit device in the next year or two. His sights are set on eventually building a 100-qubit device, which has the potential to do calculations so advanced that no conventional computer could even double-check them.

"No other place has the breadth that we have"

Physicists worldwide have developed a handful of different design strategies for a quantum computer, many of which are being advanced by work at UMD. In fact, UMD boasts top innovators in three of the approaches, as well as researchers working on hybrid approaches and young experimentalists who are about to launch new strategies.

Together, UMD's quantum scientists have as much collective knowledge as their peers at any university in the world and more versatility than at any other research center, says Sankar Das Sarma, a Distinguished University Professor who holds the Richard E. Prange Chair in Physics at UMD.

"No other place has the breadth that we have," says Das Sarma, a quantum theorist who developed the concepts underlying two of the design strategies. "The University of Maryland really is number one in quantum science." He cites two important reasons. "The university and the college have been extremely supportive of quantum science, and the JQI has become much more than the sum of its parts."

Spooky action at a distance

Rolston, JQI's co-director, divides quantum science into two phases. The first quantum revolution began in the early 20th century and involved new insights into the way materials behave at the microscopic level. "The information revolution is all about understanding materials through quantum mechanics and designing devices based on that," he says. "It

Photo by John T. Consoli

> “The really fundamental bizarre thing about quantum mechanics is that it is really not a theory about nature, but about our knowledge of nature. In other words, **there is no objective reality.**”
>
> –Steve Rolston

is transistors, magnetic storage and the laser. That’s the straightforward part of quantum mechanics.

“There is a second part of quantum mechanics that we call ‘quantum weirdness,’ these wonderful, counterintuitive things that used to be simply interesting oddities without much relevance,” Rolston says. “But in the last 20 years, as we have become very good at manipulating individual atoms, we can now exploit some of these oddities to do new things.”

To understand one important quantum oddity, you must forget the notion of opposites. In the quantum realm there is no duality, no yes-no, no on-off. Everything can exist in more than one state. An electron can spin clockwise and counterclockwise at the same time. A flipped quantum coin lands simultaneously on heads and tails. And if you hand a quantum physicist a sealed box and tell her the ball inside is either red or blue, she will set you straight: the ball is both red and blue. This capacity to be two things at once is called “superposition,” and it is the key to quantum systems’ extraordinary flexibility.

Furthermore, in the quantum world, two objects can behave in ways that are correlated, even though they have never been in contact. Physicists call this “entanglement.”

“If you flip two coins, there are four possible outcomes—heads and heads, tails and tails, heads and tails, and tails and heads,” explains David Hucul, a Ph.D. student in Monroe’s lab. “If the two quarters are entangled, they are correlated in specific ways. Let’s say, for example, the quarters are always correlated. Every time one quarter shows heads, the other quarter also shows heads. If you took one quarter and I took the other, you could fly to California and flip your coin. The result would be random, just like any other coin toss. But if it came up heads, you would immediately know that my coin also came up heads. And if you got tails, you would know instantly I got tails, even if I was on the other side of the universe.”

This seems impossible, Rolston points out, because information cannot be transmitted faster than the speed of light. But with quantum objects, the correlation is as close to instantaneous as anyone can measure. And from this simple starting point—a scrap of information shared by means of entanglement—researchers can move on to develop codes, communication networks and computation tools.

In the 1930s, Albert Einstein called the phenomenon of entanglement “spooky action at a distance.” Rolston believes it is only spooky if you are wedded to the notion of objective reality. “The really fundamental bizarre thing about quantum mechanics is that it is really not a theory about nature,” he says, “but about our knowledge of nature. In other words, there is no objective reality.”

Consider that ball in the box: it can be red, blue and simultaneously red and blue. Its real state may not only be unknown, but undetermined until the physicist opens the box and observes the color. This is quantum indeterminacy, the idea that a quantum object may have no fixed properties until the object is observed and measured.

“Whenever I measure something I disturb it. I cannot precisely measure both position and velocity of a particle, for instance,” says Rolston. “The more carefully I measure the particle’s velocity, the less certainty I have about its position.”

quantum quirks

Superposition
The capacity for a qubit to exist in two different states at the same time.

Entanglement
When two objects behave in a correlated way, though individually they behave randomly.

Indeterminacy
An object in a quantum state has no fixed properties until it is observed and measured.

Uncertainty
Any measurement of a quantum system disturbs the system, resulting in measurement errors.

Conundrums like this are both the strength and the weakness of quantum science. For example, because any measurement of quantum data is disruptive, it would be almost impossible to hack into a quantum computer or intercept communications on a quantum network without being detected. Anyone who reads a quantum message and then forwards it on to its destination would add so many errors that the interception would be noticed.

Because such a network would be much more spy-proof than today's communications systems, the U.S. Army Research Laboratory is collaborating with the JQI to test the technology by building a fiber-optic quantum link between the campus and the lab's headquarters in Adelphi, Md.

At the same time, Monroe points out, quantum uncertainty makes it hard to pause a quantum computer and confirm it is working because any measurement of the computer's qubits will alter the results. Not to mention the fact that quantum states are extremely fragile.

Quantum bits must be kept cold, as close to absolute zero (-273.15 degrees Celsius, -459.67 degrees Fahrenheit) as possible. A few molecules of air in the vacuum chamber that houses them, a thud that shakes the laboratory floor or an electrical surge in the room's wiring can cause qubits to "decohere," or slip out of superposition and become either a 0 or a 1, and thus no better than a conventional bit. In most experiments, the qubits remain in their quantum state for just a fraction of a second.

There is no question that researchers face some big challenges. They must find a way to keep qubits securely confined and reliably quantum, yet still accessible and controllable. Because they know quite a few qubits will slip out of the quantum state, they have to build in a hefty surplus to compensate. And they have to entangle the qubits in an efficient pattern so the computer will be fast, versatile, fail-safe and will continue working even if most qubits decohere.

"At some point you have to make that leap"

With so many problems to solve, it is no wonder UMD researchers are trying several different strategies.

In Monroe's laboratory, researchers heat the rare earth element ytterbium to convert it to a gas, then inject a few neutral atoms of the gas into a vacuum chamber. A laser beam strips an electron from each atom, converting them to positively charged ions. A second laser beam chills them to a few thousandths of a degree above absolute zero. Inside a gold and ceramic chip designed and built in the lab, electric fields of varying strengths and directions hold the ions still in a crystalline pattern about a tenth of a millimeter wide. Once the ions are trapped in place, the scientists use specially tuned lasers to connect them into a miniature circuit similar to those in conventional computers.

The same principles are guiding work across the hall in another of Monroe's experiments, where graduate student Hucul tracks the action in two separate vacuum chambers a meter apart. Each chamber holds a single ytterbium atom and has its own Rube Goldberg array of lasers, lenses and mirrors designed to beam a photon—a particle of light—precisely enough to hit that one ytterbium atom. Next, the two photons travel through optical cables to a beam splitter, which they strike simultaneously.

> A quantum computer could represent more information than the number of particles in the universe.

At the moment the beam splitter detects them, the two ytterbium atoms—which are still in separate vacuum chambers a meter apart—become entangled by light. Measure the way one of them spins, and researchers will instantly know which way the other one spins.

"We think this is a good architecture for a quantum computer, because a big quantum system is going to have to be modular," says Monroe. "You can keep putting more qubits on a chip, but at some point you run out of space or run into noise and you have to make that leap and link a lot of chips together."

Many quantum computing experts think Monroe's approach is the most advanced and will be the easiest to scale up quickly. It has even attracted financial support and engineering expertise from Lockheed Martin, the Bethesda, Md.-based global security and aerospace company with a 60-year history of support for UMD research. (See "Partnerships Empower Quantum Leaps," page 13.)

Quantum doughnuts

Other strategies seek to work around the delicacy of the quantum state by using materials that are potentially less sensitive to the environment. In fact, Das Sarma's ideas have inspired some of these alternative approaches.

Das Sarma and other quantum theorists use mathematics and abstract reasoning to explain the behavior of solids, liquids, superconductors and atomic phenomena that happen only in the quantum realm. In his 34 years at UMD, Das Sarma has been responsible for many breakthroughs in quantum research, including the conceptual basis for artificial atoms made from semiconducting materials, called "quantum dots," which could be used in a quantum computer. But these days, he is most excited by an approach based on what he and others call "quantum doughnuts."

Imagine any circular shape with a hole in the middle, such as a doughnut or rubber teething ring. Bite around the edges of a doughnut and it remains a ring. Twist a baby's teething ring and the ring keeps its original shape.

Researchers who specialize in topology —the study of these resilient shapes—think they are ideal for building quantum computers. A design that encodes information in this shape could overcome the fragility of quantum superpositions because a ring is still a ring no matter how you deform it. Rings of qubits could be braided together into circuits that would keep working even if many of the qubits decohered.

In 2005, Das Sarma collaborated with

The New Frontier

In the 1920s, physicist Albert Einstein predicted that certain gases would behave in strange ways under quantum conditions. As a young researcher launching his career in the 1970s, William Phillips worked simultaneously on testing Einstein's prediction and finding a way to cool atoms to keep them in a quantum state. The latter work earned Phillips the 1997 Nobel Prize in physics and was critical for producing the peculiar matter that Einstein predicted.

Today Phillips is a College Park Professor in Physics and co-director of the Joint Quantum Institute's (JQI) Physics Frontier Center, working with researchers who continue to explore Einstein's prediction and other quantum conundrums. Established in 2008 with a five-year, $12.5 million National Science Foundation (NSF) grant, the center supports researchers in atomic physics and condensed matter physics, which includes studies of solids, liquids and exotic phases of matter. Physics Professor Luis Orozco also co-directs the center, which is one of 10 NSF-funded physics frontier centers. This summer, the NSF renewed its support to the center for another five years.

Many of the center's scientists, like Assistant Professor of Physics Gretchen Campbell, are conducting basic research aimed at advancing our understanding of the quantum world. Campbell, who is also a JQI Fellow, is a pioneer in atomtronics, an emerging field in which scientists use ultracold atoms to build circuits with the same superconducting properties as some electronic circuits. "This field keeps growing, and we keep discovering new things we can do," says Campbell, who won a Presidential Early Career Award for Scientists and Engineers in December 2013.

She studies the peculiar quantum material that Einstein predicted in 1924, but was not produced in any lab experiments until 1995. This substance, called a Bose-Einstein condensate of atoms in the gas phase, displays one of the deeply strange aspects of quantum mechanics. In the quantum realm, everything—a desk, a lamp and its light—behaves as both a particle and a wave. In the world of classical physics, we see objects as either particles or waves. But in the quantum realm, wave-particle duality means that sometimes we see both.

GRETCHEN CAMPBELL

Campbell takes a few grams of sodium or strontium and heats them in a tabletop oven to 600 degrees Celsius (1,112 degrees Fahrenheit) to produce a tiny fraction of a gram's worth of gaseous atoms. She then uses lasers and magnetic fields to chill them to within a few billionths of a degree of absolute zero, the coldest temperature possible. "They get cooler and cooler, move slower and slower, and get closer and closer together," she says. "Eventually we can no longer distinguish one atom from another. At this point, we could call them either a particle or a wave."

The gas has now become a Bose-Einstein condensate—an ultracold superfluid that is not simply a collection of separate atoms but a single entity, frictionless and free flowing. In Campbell's sodium experiment, the condensate flows inside a ring formed by laser beams. Campbell stirs the atoms with another laser beam just as she would stir coffee with a spoon. At a critical stirring speed, Campbell sees the entire gas suddenly move faster, as if every particle in the condensate jumped en masse into high gear.

That jump in speed could lead to a quantum counterpart for today's inertial sensors, which measure acceleration, rotation and other kinds of motion. Today's inertial sensors are components in many kinds of instruments that must adapt to movement, from a smartphone's compass app or a video camera's image-tracking mechanism to an airliner's navigational system. Quantum inertial sensors may guide planes and submarines more accurately, and therefore more safely. "The research is in the earliest stages," says Campbell. "It's possible there are other atomtronic sensors that will be useful."

Campbell and colleagues in the Physics Frontier Center say they are not only interested in potential applications, but also profoundly excited by the chance to explore the mysteries of the quantum realm.

"What appeals to me is understanding how things work and the underlying laws of nature," says Jonathan Hoffman, a Ph.D. student who works with Orozco and JQI co-director Steve Rolston in the center. "The idea of inventing something new is fascinating. But more important, I like exploring new ideas in physics."

quantum quirk

WAVE-PARTICLE DUALITY
Everything is both a particle and a wave, at the same time.

Photo by Loretta Kuo

a Microsoft physicist and several other colleagues to introduce the concept of the braided topological qubit. Five years later, Das Sarma and colleagues proposed that by layering certain superconducting metals like a sandwich, researchers could create special particles, called Majorana fermions, which could act as qubits in a topological quantum computer. Preliminary proof-of-principle studies show these qubits can be made in lab conditions that are not as exacting as the ones needed for Monroe's ion trap design.

"You need low temperatures, but not anywhere near as low as other approaches, and a much lower magnetic field," says Das Sarma. "We call this 'generic topological computing,' because it's relatively easy to do." The next step is for experimentalists to build a prototype that links some Majorana fermions together to function as qubits.

One of JQI's newest scientists plans to do that. But first, Vladimir Manucharyan is setting up a laboratory in the new Physical Sciences Complex, where he plans to take an entirely different approach to quantum computing. Born in Azerbaijan and educated at Moscow Technological Institute and Yale University, Manucharyan joined JQI and the Department of Physics as an assistant professor in January.

Where Monroe captures individual atoms, holds them in that strange multiple-identity quantum state and connects them together, Manucharyan's approach draws on ideas from electrical engineering. He builds precise electronic circuits that use a special type of quantum transistor. But otherwise, he explains, "they work just like a regular circuit from Radio Shack." He chills the circuits to nearly absolute zero in a special $500,000 refrigerator imported from Finland. The ultracold circuits are superconductors, carrying an electrical current in perpetuity without generating any heat. Manucharyan says these circuits can be manipulated into behaving like networks of qubits with the same characteristics as Monroe's trapped atoms.

The superconducting electronic circuits Manucharyan builds do not lose energy, so they are more stable. The circuits are bigger than the single atoms in Monroe's ion traps, but they are still difficult to build, link together and get into a quantum state.

Manucharyan likes the fact that experts in other quantum systems are a few doors down the hall, because it makes brainstorming with colleagues much easier. "We hope to learn what Chris does with his ions, and vice versa," Manucharyan says. "To have more than one approach in the same department is very, very helpful."

Manucharyan plans to launch another experiment with Das Sarma's Majorana fermions next year. "I find this approach fascinating because it involves fundamental questions of physics and new states of matter," Manucharyan says. "It requires a lot of technical skills, but I think we can actually make it work."

Asking the questions that really matter

Eventually, in 10 or 20 or 50 years, the first quantum computer will become a reality. Then what?

"Right now, there is a limited set of things that we know we can do easily through quantum mechanics that we cannot do easily

Photo courtesy of Microsoft

DOUGHNUT THEORIST: SANKAR DAS SARMA

TOPOLOGICAL QUANTUM COMPUTING THEORIZES THAT "QUANTUM DOUGHNUTS" COULD BE BRAIDED TOGETHER TO FORM A STABLE QUANTUM COMPUTING SYSTEM.

Their Real World is Quantum

CHAD ORZEL

"Learning to appreciate quantum physics is largely a matter of learning to put aside our intuition for how the world 'ought' to work and looking at what really happens," says Chad Orzel, Ph.D. '99, chemical physics. A physics blogger, lecturer and author, Orzel has helped thousands of students and citizen scientists understand quantum weirdness in his 13-year career at Union College in Schenectady, New York, where he is an associate professor and chair of the Department of Physics and Astronomy. "There's nothing better than seeing the moment when a student 'gets' a new and strange idea," says Orzel, who studies laser cooling and trapping of krypton atoms. The author of "How to Teach Physics to Your Dog," Orzel's new book, "Eureka: Discovering Your Inner Scientist," is due out in December. "It is about the ways that scientific thinking shows up in everyday activities like solving crossword puzzles and playing basketball," he says.

ANA MARIA REY

In 2013, when researchers at the National Institute of Standards and Technology unveiled the most accurate atomic clock ever built, physicists hailed it as a breakthrough made possible by the ideas of theoretical physicist Ana Maria Rey, Ph.D. '04, physics. Rey's work provided the theoretical underpinning for the development of this atomic clock and similar experimental devices, says Joint Quantum Institute Co-Director Charles Clark, Rey's former Ph.D. advisor and an expert on ultracold atoms. "I still enjoy fruitful collaborations with the colleagues I met at the University of Maryland," says Rey, now an associate professor of physics at the University of Colorado Boulder and a research fellow at JILA. In September 2013, she received a MacArthur Fellowship for theoretical work that has inspired experimentalists in several quantum specialties. In announcing the $625,000 unrestricted "genius grant," the John D. and Catherine T. MacArthur Foundation praised Rey's creativity in "advancing our ability to simulate, manipulate and control novel states of matter through fundamental conceptual research on ultracold atoms."

JONATHAN MIZRAHI

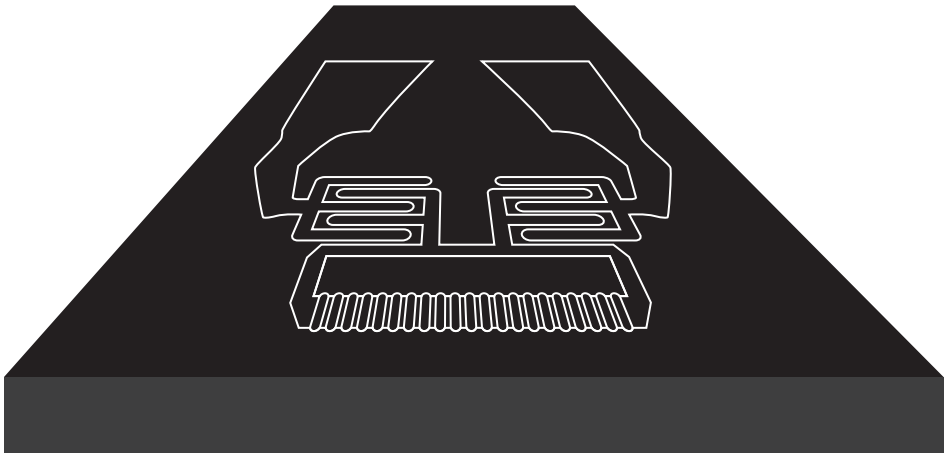
A useful quantum computer will have to be fast, controllable and scalable —not a prototype with dozens of qubits, but a product with thousands of them. "We are getting pretty good at controlling 10 ions," says Jonathan Mizrahi, Ph.D. '13, physics. "However, we want someday to be working with thousands or even millions of ions. That will require new approaches and new techniques." At UMD, Mizrahi worked on ultrafast control of qubits in ion traps. As a postdoctoral researcher at Sandia National Laboratories, he is testing, characterizing and experimenting with microfabricated ion traps. The mass-produced traps, made using the same technology as standard computer chips, can advance quantum computing from handmade assemblies to large, complex arrays. "We are almost to the point where we have extraordinary quantum control at the finest level over arrays of individual atoms," says Mizrahi.

ALUMNI
WORKING IN QUANTUM

QIUZI LI

Qiuzi Li, Ph.D. '13, physics, has discovered that quantum theorists' skills, such as the ability to use mathematical analysis and insights drawn from physics to predict the hidden properties and behavior of materials, are valuable in corporate research. At UMD, Li conducted research in the Condensed Matter Theory Center, and was a prolific author, a Women in Physics mentor and coach of the U.S. Physics Olympiad team. Today, she is a senior researcher working as a theorist in the field of geophysics at Exxon Mobil Research and Engineering Company in Annandale, N.J. Li says her job is to guide research that "addresses key technical needs and enables novel technology in the energy industry." Basic research is far from irrelevant to daily life, she says. "Fundamental science can lead to technologies that have a direct impact on solving the world's biggest energy challenges."

Orzel photo by Steve Jacobs / Rey photo courtesy of the MacArthur Foundation / Mizrahi photo courtesy of Jonathan Mizrahi / Li photo by Haitan Xu



CIRCUIT CHILLER: VLADIMIR MANUCHARYAN

EACH OF MANUCHARYAN'S ELECTRONIC CIRCUITS ACTS LIKE A SINGLE ATOM. WHEN CHILLED TO NEARLY ABSOLUTE ZERO, THE CIRCUITS CARRY AN ELECTRICAL CURRENT IN PERPETUITY WITHOUT GENERATING ANY HEAT, AND EXHIBIT QUANTUM BEHAVIOR.

with a classical computer," says JQI Fellow Jacob Taylor, a NIST physicist who specializes in quantum information theory.

Some of the advantages are well studied and widely accepted. For example, a quantum computer can find the factors of a large number exponentially faster than a classical computer. That could render existing technology for online commerce obsolete, because today's most widely used encryption technology is based on the difficulty of factoring long numbers. "If everybody has a quantum computer, the current encryption technology is no longer secure," says Taylor.

Researchers agree a quantum computer will quickly find patterns within huge databases that are too big to search with existing computers. In the "big data" age, when all sorts of personal information is archived, that could be a major boon to many fields, such as medical research. A quantum computer could help chemists develop complex new medicines made up of hundreds of molecules, says Rolston. And in game theory, a quantum computer could identify the pivotal points on a decision tree, or "the few questions that really matter, while the rest are irrelevant," explains Taylor.

But the new machines will likely be error-prone and vulnerable to hacking. "Almost always, the weakest link in any system is a person whose credentials have been compromised," Taylor says. "That is not going to change. So you have to look at the computer's overall infrastructure and ask which parts of it are going to be broken and which parts of it can be fixed."

In October 2014, Taylor, UMD Distinguished University Professor Emerita in Computer Science Dianne O'Leary, and colleagues at the university's Institute for Advanced Computer Studies established the Joint Center for Quantum Information and Computer Science (QuICS), a partnership between the University of Maryland and the National Institute of Standards and Technology, with the support and participation of the Research Directorate of the National Security Agency/Central Security Service. Taylor is co-directing the center with Computer Science Associate Professor Andrew Childs. In QuICS, quantum theorists will explore these questions and many more.

Photo by Loretta Kuo

QuICS researchers aim to answer questions that fall into four categories: How does our knowledge of quantum mechanics change our understanding of what computers can do? How does our knowledge of the capacity of quantum computers change our understanding of nature? How can a technological society keep its information secure in a quantum world? And finally, given all the imperfections and challenges of quantum computing, how do we go forward into the second information revolution?

As if those questions were not enough to think about, Taylor is also working to understand quantum systems and sensors. He is collaborating with other researchers at NIST and UMD to develop quantum magnetic sensors for use in biological assays and a quantum device that precisely measures gravitational fields. Such a sensor could guide airplanes from takeoff to landing if GPS systems fail, and find oil underground or submarines beneath the ocean's surface.

A new invention, a new understanding

The race to create a quantum computer is just beginning. "A demonstration in the lab is maybe 10 years away," says Das Sarma. "A marketable quantum computer is probably 25 to 30 years away."

Meanwhile, the college's work is contributing to both basic and applied science in much the same way the Apollo space program did in the 1960s.

"We are really coming to understand quantum mechanics at the macroscopic level," Das Sarma says. "How do quantum states disappear? What do you have to do to keep quantum states alive forever? How can we see quantum behavior in thousands or millions of atoms simultaneously? All of these are big questions that lead to a quantum computer, and they lead to an understanding of nature too."

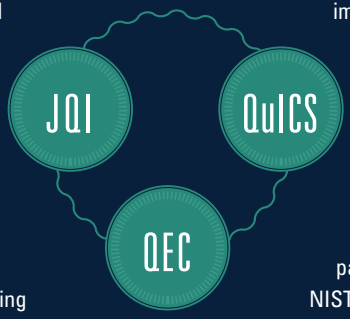
Dean Jayanth Banavar agrees, noting that this research will ultimately benefit humankind. "This will not be an evolutionary change, but a revolutionary change. We are poised to create the next revolution here at the University of Maryland, and the future is going to be breathtakingly exciting." ■

Partnerships Empower Quantum Leaps

By launching two new centers devoted to specific aspects of quantum science, the University of Maryland is building on the model partnership that makes its Joint Quantum Institute (JQI) a leader in quantum physics research.

Founded in 2006, JQI is a research partnership between UMD and the National Institute of Standards and Technology, with the support and participation of the Laboratory for Physical Sciences. The institute is home to 34 fellows—senior researchers who are on JQI's permanent staff—and over 100 students, postdoctoral researchers and visiting scientists. JQI scientists study the physical properties of the microscopic world. The institute's strength is in quantum information, broadly defined to cover communication networks, sensors, computers, quantum simulators of complex materials, and dozens of other topics in basic and applied science. JQI is co-directed by UMD Physics Professor Steve Rolston and NIST Fellow Charles Clark.

One of JQI's founding members is College Park Professor of Physics William Phillips, who shared the 1997 Nobel Prize in physics for using laser light to cool and trap atoms. "Our work *sometimes* has to do with practical things," says Phillips, who is also a NIST Fellow. "It *always* has to do with really fundamental quantum mechanical problems and with understanding more clearly the way the world works."



From the bench to the factory floor

UMD's longstanding research partner, Lockheed Martin, signed an agreement with the university in March establishing the Quantum Engineering Center. The center's mission is to develop a working quantum computer under the leadership of Bice Zorn Professor of Physics Christopher Monroe.

Monroe has been working on the design for a quantum computer since 1994. His newest experiment uses a manufactured 50-electrode silicon chip, replacing the hand-built chips used in earlier versions and making the innovation robust and reproducible. Monroe hopes Lockheed Martin's engineers will push the production process along.

"Lockheed's engineers can take our handcrafted process and turn it into an assembly line, and that's what we need," Monroe says. "Our goal is to build a device where you don't have to know its inner workings. You just use it. That requires serious engineering. I think a 10-year time frame is reasonable to develop such a device."

Preparing for a quantum future

Completing the circle of quantum science expertise, the university's new Joint Center for Quantum Information and Computer Science (QuICS) will tackle questions about the uses for such a computer and its impact on science and society.

The center, which resides in the University of Maryland Institute for Advanced Computer Studies, was officially launched in October with a $2 million, two-year federal grant. A partnership between UMD and NIST, with the support and participation of the Research Directorate of the National Security Agency/Central Security Service, QuICS is co-directed by JQI Fellow and NIST Physicist Jacob Taylor and Computer Science Associate Professor Andrew Childs.

The researchers will think through the possibilities and limitations of a computer that does not yet exist. The futuristic nature of their work poses certain dilemmas. For example, "If you want to understand the performance of a classical algorithm, you can just run the algorithm and see how it works," says Childs. "Understanding quantum algorithms is harder because we can't yet run them."

QuICS researchers want to better understand the kinds of tasks quantum technologies can handle better than conventional ones and what a quantum computer can teach us about the quantum nature of our world. "Exploring that boundary between the two realms is our main focus," says Taylor.

Young Scientists, Ancient Discoveries

K-12 students and UMD researchers join forces to find and identify shark fossils.

Across the nation, elementary, middle and high school students are experiencing the thrill of discovering shark teeth fossils that are tens of millions of years old—and of receiving credit for their work in scientific journals. The students' experience is courtesy of SharkFinder, a citizen science project led by University of Maryland Entomology Instructor Bretton Kent and sponsored by Paleo Quest, a nonprofit that advances the science of paleontology.

One such student scientist is seven-year-old David, of Bethesda, Md., a young fossil lover who discovered SharkFinder during the 2014 USA Science & Engineering Festival in Washington, D.C. After watching David investigate sample kits at the event, Kent personally invited the boy to work in his lab.

On Thursdays during his summer break, David's mother drove him to College Park to sort fossils in Kent's laboratory. There, David says he searched for rock samples with "especially hard surfaces, serrated edges or curiously shaped holes," all of which could suggest evidence of an ancient sea creature. During his first two weeks in the lab, he found possible fossils of worm tunnels, ray plates and shark teeth.

"It's not every day that you can find a shark tooth!" exclaims David, who credits SharkFinder with giving him new opportunities to fossil hunt.

Fossil samples are collected by Paleo Quest staff from sites in Virginia and Maryland, including the Calvert Formation, part of Calvert Cliffs State Park in southern Maryland. Calvert Cliffs is famous for fossils from the early Miocene period, between 20 and 10 million years ago. Staff send the sediment samples, along with tweezers and magnifying glasses, to students across the country. The students, with the aid of fossil photographs, identify potential fossils and mail them to Kent's laboratory.

In Kent's lab, undergraduate students sort through the samples, many of which are too worn or damaged to confirm as fossils. Because the shark teeth are so tiny—often no more than one or two millimeters—Kent's students use a state-of-the-art dissecting microscope to visually determine the species of origin for intact specimens. Identified fossils are curated and displayed at the Calvert Marine Museum in Solomons, Md.

Since SharkFinder efforts began two years ago, student participants have found more than 25,000 fossilized teeth. Kent's group is currently preparing nine research papers on recent findings, all of which will credit the K-12 students who contributed fossils or photographs.

A lack of information on shark species' fossils in Maryland led Kent to launch the program. Though he knew the Calvert Cliffs area potentially contained tens of thousands of fossil samples, he did not have enough time or manpower to excavate and identify them himself. An experienced citizen science organizer—SharkFinder is his third such project—Kent believed this project was a prime opportunity to involve the public in science, engage students in research and gather new paleontological data. Kent decided to collaborate with Paleo Quest, an organization dedicated to advancing the state of education, exploration and contributions in paleontology and geology.

"After I teamed with Paleo Quest, our biggest challenge was figuring out how to organize and transport the sheer volume of material from Calvert Cliffs to classrooms across the country and then back to the lab," explains Kent, noting that tens of thousands of schools across the nation now participate in the program. He is eager to add even more schools to that list.

SEVEN-YEAR-OLD DAVID (CENTER) HELPS IDENTIFY SHARK TEETH WITH ENTOMOLOGIST BRETTON KENT (LEFT) AND BIOLOGY LAB COORDINATOR HANS LEMKE (RIGHT).

The group's goals include developing new tools to train current teachers and students in identifying the species of origin of fossils. "We hope to show students how science is done by giving them the chance to participate in the real thing," adds Kent.

Although the majority of the young shark finders are not applying to college or jobs yet, Kent anticipates the program will inspire students to pursue paleontology research careers.

David, though, needs no further convincing. "I hope that SharkFinder will be the start of my career in fossil hunting," he says. ■

–IRENE YING

FOR MORE INFORMATION ON SHARKFINDER, VISIT WWW.SHARKFINDER.ORG OR EMAIL INFO@PALEOQUEST.ORG

Photos by Loretta Kuo

GAME CHANGER

Brendan Iribe Continues To Show His Vision

By Lauren Brown

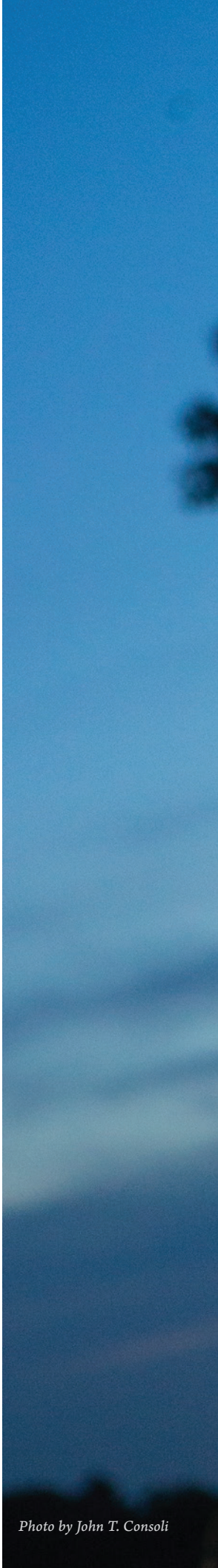


Photo by John T. Consoli

TAKE A COMPANY FROM ZERO TO $2 BILLION IN 20 MONTHS, AND DON'T BE SHOCKED WHEN YOUR FRIENDS, FAMILY AND INVESTORS WANT TO CELEBRATE WITH YOU.

Brendan Iribe's surprise bash, held just days after Facebook acquired Oculus VR, the business he co-founded and leads as CEO, looked like something straight out of "This Is Your Life."

Guests who'd secretly flown to Southern California included the elementary-school buddies he played video games with. The college roommates he entertained with visions of his first business. The computer programming wizards he recruited over the past 15 years. His mother, Elizabeth, who supported him in every venture and helped organize the celebration.

Back on the East Coast were other happy investors, like the tech company guy who gave him his first programming job at age 15 and the uncle who pitched in with seed funding and accounting at the video-game software firm Iribe and two friends started at the University of Maryland.

Iribe had convinced people from every stage of his 35 years to support Oculus VR. Now, many of them stood beside him to toast the company's success and future. Oculus was this much closer to developing a totally immersive 3-D virtual reality (VR) experience, one that has the potential to transform entertainment and social communication.

"After a while it was a no-brainer. I've invested in every company he's ever created," says Ernie Falcone, B.S. '86, electrical engineering, who employed Iribe in high school and college. "Brendan is a decent programmer. He's an incredible visionary."

Iribe rose to success through uncanny instinct, intelligence, unwavering confidence and shrewd business sense, along with a fervent loyalty to the friends he cultivated along the way.

"Steve Jobs really hit it when he said the journey is the reward," Iribe said in September, as he announced he was committing $31 million to UMD—the university's largest single gift—to construct a new computer science building. "But I would add that the memories and the relationships are what last forever on that journey."

On stage with him during the announcement stood the foremost example of his enduring friendships and his ability to identify the best people in the industry to execute his ideas. Iribe's longtime business partner (and former Denton Hall floormate) Michael Antonov, B.S. '03, computer science, now co-founder and chief software architect at Oculus, donated $4 million toward construction of the building and computer science scholarships.

Their first company, Scaleform, sold for $36 million. Their second, Gaikai, went for $380 million.

Now Oculus bears the title of the first Kickstarter-funded startup to become a multibillion-dollar company. VR experiences using the Oculus Rift goggles and software stole the show earlier this year at Comic-Con in San Francisco and South by Southwest in Austin. Blown-away bloggers and tech writers have proclaimed the Rift the next big thing in computing, and over 75,000 new developer kits have been sold. And everywhere, there is Iribe, the who-needs-sleep? leader, the device's greatest evangelist.

"It's hard to understate the impact VR is going to have," Iribe says. "We can replace what you see in the world with anything we want."

BORN TO LEAD

Iribe had too much charisma to ever be a traditional tech geek.

He was raised by his mother, first in a 100-year-old farmhouse in western Virginia, then in Howard County, Md. There she married Alan Peters, a chemist who cultivated Iribe's budding interest in computers and video games—Mario, the Legend of Zelda, Commander Keen and Doom.

In the early 1990s, Peters helped a preteen Iribe buy his first computer, an original IBM PC 086. While playing video games, Iribe realized that he could freeze his shoot-'em-up game to stare at the 1s and 0s in the memory. He started hunting for patterns and soon figured out how to modify the programming code to give himself unlimited lives and ammunition. Then he boosted his popularity at school by sharing a program with friends to run on their home computers.

"Everybody wanted it," he recalls. "'You're still dying? Here's my program to stop that.'"

At Atholton High School in Columbia, Md., computer science teacher and soccer coach Reg Hahne told the sophomore he didn't make the team, but said Iribe was a better fit in his classroom.

"He was eclectic and intense," says Hahne, who still keeps in touch with Iribe. "He always wanted to ask the next question: What if? What if? He was never satisfied. He always wanted to do better."

By 15, Iribe landed his first job, working for Wayne Moore, founder of Department of Defense engineering subcontractor Microcosm. Iribe was one of several gifted and talented students in Howard County schools employed by Moore to develop new software and to build a video game for his new company, Alien Software.

"I didn't know what I was doing," Moore says. "Brendan shouldn't have known what he was doing. But he knew immediately how to organize these guys. He figured out you should be doing this, and you shouldn't be doing that. He totally reframed the entire effort."

Moore shut down the effort, though, when he couldn't get a production company to put the game on the market, which was just being taken over by 3-D gaming.

Until then, Iribe says, "We had so much fun, eating pizza and subs every night while we worked late and played games. We were soaking up and learning. Wayne paid for this awesome education for me and nearly a dozen students."

Iribe took that education to his second high-school job with a museum-exhibit designing firm in Laurel, Md., called Quatrefoil. At age 16, he was a lead programmer, cranking out multimedia programs.

"HE ALWAYS WANTED TO ASK THE NEXT QUESTION: WHAT IF? WHAT IF? HE WAS NEVER SATISFIED. HE ALWAYS WANTED TO DO BETTER."

Photo by John T. Consoli

"What we needed him to do, he was well suited for," says Falcone, who founded the company with his wife, Abbie Chessler. "It wasn't the artist part—it was the creative part of developing engaging exhibits and getting people jazzed. That's what he's still doing. He just got better and better at it."

THE BOLD AND THE BRAINY

What changed everything for Iribe was meeting Antonov, a Steve Wozniak to his Steve Jobs.

They roomed across the hall from each other when they arrived at Maryland, and never did two students seem so different. Antonov, a Russian immigrant who grew up in Owings Mills, Md., was shy and bookish. He had started programming on a calculator, then in high school created games for his home PC.

Still, he and Iribe hit it off, and Antonov suggested they create a game together. Iribe was still working full time at Quatrefoil (and accumulating more than 200 campus parking tickets as he zipped back and forth—Falcone promised to pay them if it meant Iribe could stay at the office longer). Iribe jokes now that he "squeezed in" classes between all the time he spent working and gaming with friends.

Iribe decided to take off the following year to focus on Quatrefoil's project building the music lab for the Experience Music Project Museum in Seattle. He didn't quite leave the university, though.

One day in fall 1998, he drove by Antonov walking along Route 1, pulled over and offered him a ride home. Back in Antonov's dorm room, Antonov showed Iribe an operating system he made in high school and the games he recreated using it. Iribe was stunned by their sophistication.

"Where did you learn to make all these games?" Iribe asked.

Antonov said he taught himself by reading programming books. He pointed to a stack of black and white composition notebooks. Inside them, in the tiniest print, he'd copied hundreds of pages of programming instruction from library books.

"You're a genius and you're crazy," said Iribe, who immediately recognized a bigger opportunity to start a company with Antonov.

Their idea was to produce a new computer multimedia windowing system with richer graphics and gaming hooks than Microsoft's. Sven Dixon, who had worked with Iribe at Alien Software as a digital artist, joined the team, along with Antonov's roommate and a fellow programming whiz, Andrew Reisse, B.S. '01, computer science, to launch their startup, Sonic Fusion, which was later renamed Scaleform.

"We were in a little bit over our heads," Iribe says now.

GROWING PAINS AND GAINS

What may seem like an overnight success story really took years. Iribe convinced Antonov to take a break from school to get Sonic Fusion off the ground. (Antonov's parents balked at that move, though, and he soon returned to Maryland part time.)

Reisse took a break from the programming workload when he couldn't afford to work without a paycheck, and a broke Iribe and Antonov moved into Iribe's mother's house shortly after Iribe's stepfather passed away.

Falcone, who had started another business called Mars Labs, and Iribe buckled down together to find investors for their companies among their friends, families and strangers.

"We never read books on raising venture capital," Falcone says. "We just did it."

Iribe's mom and uncle pumped in additional funding as he and Antonov headed out to their Laurel office by 9 a.m. and returned after midnight, day after day, for four years.

Then they got the idea to drive out to California to convince some of their programming idols to support Scaleform. That met with only limited success, and they worked nonstop in a nearly empty apartment for months before returning to Iribe's mom's house.

Finally, they licensed their technology to Firaxis in Hunt Valley, Md., for a game called Civilization IV. It went on to be named 2005 Game of the Year by several gaming websites.

"Five years of our lives we slaved on this thing," Iribe says. But he and Antonov realized their work couldn't be scaled—it required too much technical support to tackle customers' problems. They decided to drop it entirely, and start over. "That was a really hard decision to make," Iribe recalls.

Yet another idea emerged from all of his networking: a slick, compact, high-speed, graphically beautiful interface system that would integrate easily into game engines and allow developers to use the Adobe Flash authoring tool. "Somehow I convinced Sven and Mike to stay with me and keep cranking

IRIBE WORKING AT THE QUATREFOIL OFFICE AS A TEENAGER.

Photo courtesy of Elizabeth Iribe

to make this whole new product. I thank them all the time for not bailing, because at the end of the day, Sven created all the graphics and Mike wrote all the code. I just went out there to try to sell it," Iribe explains.

Scaleform opened an office in Greenbelt, Md., where it remains today, and grew its staff to about 30 people. Their first product, GFx, got licensed throughout the industry and was featured over the next few years in hundreds of PC, Wii, PlayStation 3 and Xbox 360 games, including Crysis, Mass Effect and Gears of War 3.

In February 2011, after more than a decade of relentless work, Autodesk acquired Scaleform, and Iribe began looking for a new opportunity. Nate Mitchell, who was first hired by Iribe as a Scaleform intern and is now vice president of product at Oculus, says Iribe's exit was a blow, temporarily: "The energy left the building so fast you wouldn't believe it. He really did serve as an Energizer Bunny, powering the speed and momentum of the company."

Iribe landed at a cloud gaming company in Southern California called Gaikai, and Antonov, Reisse and Mitchell soon followed. Their goal: to make gaming consoles obsolete by allowing gamers to rely on the cloud to stream to smart TVs. Sony, which was working on a cloud platform for PlayStation 4, bought the company within a year.

"We were starting to get the hang of this," Iribe says jokingly.

THIRD TIME, ANOTHER CHARM

With Oculus, Iribe again revved up a life already in overdrive.

A friend offered to introduce him to Palmer Luckey, who as a home-schooled teenager had cobbled together a VR headset called the Oculus Rift, made of cellphone parts and a goggle-like frame. Luckey predicted that it would someday offer true immersion—the holy grail of gaming.

As the now-legendary story goes, word reached John Carmack, creator of the Doom and Quake franchises who is widely considered the father of 3-D, first-person-shooter games. Carmack contacted Luckey, asking to show the Rift to a few people at E3, the premier video gaming conference.

Luckey sent him one of only two prototypes. (He later told Iribe: "It's like Jesus asking to borrow your clothes. You just give them.") And those "few people" turned out to be nearly a dozen reporters.

BUSINESS PARTNERS FOR 16 YEARS AND COUNTING. ABOVE: IRIBE HOLDS THE SONIC FUSION BUSINESS PLAN AND ANTONOV HOLDS THE TECHNICAL SPECIFICATION IN 1999. BELOW: THE TWO FRIENDS REVISIT DENTON HALL, WHERE THEY FIRST MET AS UMD FRESHMEN.

Carmack declared it not just "fundamentally cool," but "the best VR demo for this kind of thing ever made." He expressed confidence that several major improvements could be made quickly and that the Rift headset would be available to consumers in the near future.

The Rift was a sensation and was awash in a tidal wave of positive press in June 2012 when Iribe agreed to take a closer look.

Yes, the duct-taped device was clunky and had serious problems, such as blurriness, a too-narrow field of vision, multiple cords to get tangled around and time lag that—like every other attempt at VR—made Iribe nauseous within seconds. But he saw potential.

"Mike, Nate, Andrew and I put our heads together and thought about what this could really become and where this could really go," he says. "We got incredibly excited about it."

The foursome agreed to form Oculus VR with Luckey and launched a $250,000 Kickstarter campaign to fund the mind-boggling amount of R&D required to improve the Rift. They produced a video over the next two weeks featuring testimonials from some of the biggest names in the gaming industry. The crowdfunding effort raised $800,000 in the first 24 hours, ultimately netting over $2.4 million in 30 days.

Carmack quit his job as co-founder of id Software to become chief technology officer at Oculus. The company raised over $90 million in venture capital and, with the help of Valve Software in Washington state, made huge strides improving the Rift, including the ultra-low latency 360-degree positional tracking and rendering needed to avoid disorientation. Users looking right and left and tilting their heads up and down get the sense of "presence"—of being in another world. "Working closely with Valve, we finally cracked the code and proved we could deliver a comfortable experience that everyone enjoyed, even the most sensitive users like me," says Iribe.

Other possibilities for the technology beyond gaming quickly became apparent: teach children about the solar system, help medical students learn how to perform surgery, take homebound (or cash-poor) users on virtual vacations and even put fans in the middle of sporting events.

The Rift won every best-of-show or best product award at major trade shows

Photo courtesy of Elizabeth Iribe / Denton Hall photo by Mike Morgan

Pictured from left to right:

1. Brendan Iribe and Elizabeth Iribe (1982)
2. Alan Peters, Brendan Iribe and Iribe's grandmother Anita M. Iribe (1991)
3. Sven Dixon, Ernie Falcone, Brendan Iribe, Michael Antonov and Andrew Reisse at Sonic Fusion (1999)
4. Ernie Falcone and Brendan Iribe (2000)
5. Brendan Iribe, Dana Reisse, Michael Antonov and Robert Reisse (2014)
6. Brendan Iribe and Wayne Moore (2014)
7. Brendan Iribe and Elizabeth Iribe (2014)

"Steve Jobs really hit it when he said the journey is the reward. But I would add that the memories and the relationships are what last forever on that journey."

Photos 1-4 courtesy of Elizabeth Iribe / Photos 5-7 by Lisa Helfert

and wowed attendees at South by Southwest Interactive this past March, where fans lined up for hours to step into a "Game of Thrones" simulation in which they could reach the top of "The Wall" up a rumbling elevator and stand amid whipping winds. Their mouths hung open in amazement—what Iribe calls "the Oculus face."

It wasn't long before Facebook founder and CEO Mark Zuckerberg visited Oculus to test the latest prototype himself. He and the Oculus leadership talked about the difficulty of eliminating motion sickness and the hardware engineering still needed: custom optics, screens, sensors and cameras. Building and manufacturing a consumer-ready platform was going to cost hundreds of millions of dollars. Speaking with Zuckerberg, Iribe laid out his vision: "Oculus is going to revolutionize not just gaming and entertainment, but the way humans interact. You'll truly believe you're in a new virtual environment and you won't be alone. Virtual reality is the only platform that can connect everyone face-to-face. Imagine the whole world is in a pair of glasses."

An impressed Zuckerberg acknowledged that Oculus had gaming figured out and Facebook knew social networking and communication. Together, they could connect a billion people in virtual reality.

Within three days, they'd hammered out the essentials of a deal for Facebook to acquire Oculus. The deal allowed the startup to keep working autonomously, but with vastly more financial support.

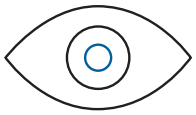
"Oculus has the chance to create the most social platform ever, and change the way we work, play and communicate," Zuckerberg said in the official announcement.

It was news around the globe. Iribe and Co. were the darlings of the tech world—and 10 days later, he and Antonov were headed back to the University of Maryland.

CREATING THE FUTURE

Iribe and Antonov had reconnected with the university only a year earlier under the most heartbreaking of circumstances. Reisse, an Oculus co-founder and lead engineer, and an avid hiker and photographer, was killed in a hit-and-run accident near his Santa Ana, Calif., home in May 2013.

Iribe, Antonov and their co-workers, along with Reisse's parents, Robert, M.S. '70 and Ph.D. '76, physics, and Dana, M.L.S. '73, library and information services, quickly funded a new scholarship for Terp computer science students in his name.



IT JUST HIT ME AND I SAID, 'WE CAN HELP. HOW MUCH IS A BUILDING?'

"We wanted Andrew to be remembered and to support the kind of independence, creativity in computer science and the love of nature, which he had," Antonov says.

He and Iribe were invited back to Maryland for Bitcamp, an April 2014 event that drew 700 students nationwide to hack together websites, apps and computer hardware projects.

Computer Science Department Chair Samir Khuller worried that amid the Oculus news frenzy, the pair would back out. Instead, they spoke to a standing-room-only crowd, donated more than 40 Rifts to the deliriously happy student hackers and toured their old stomping grounds in the A.V. Williams building.

Passing the computer science classrooms and research labs carved out of the building, which opened in 1987 as office space, Iribe recalls, "My first thought was, this is pretty depressing. How can people get inspired to create the future in a space like this?"

Someone mentioned that computer science needed a new home. "It just hit me and I said, 'We can help. How much is a building?'" Iribe remembers.

In August, Iribe signed the paperwork to give the University of Maryland $30 million to fund the Brendan Iribe Center for Computer Science and Innovation, and another $1 million for scholarships. Antonov followed suit, pledging $3.5 million for the building and $500,000 for scholarships. Elizabeth Iribe, her son's most loyal investor, gave $3 million to endow two professorships in computer science.

Iribe likes the ideas of "giving while living," as well as encouraging students to create and researchers to explore the potential of virtual reality, while making the University of Maryland a national model in this field.

"It's fun to do this project when virtual reality is about to take off, and the center is going to be there right from the beginning," Iribe says. "There's going to be an environment at Maryland that fosters creativity and innovation in computer vision, robotics, virtual reality and everything that is impactful in computer science."

In the meantime, he's still pushing to get the Rift to the market—he deflects the near-daily question of "When?" Oculus has grown to more than 200 employees at offices in Seattle, Dallas, and Menlo Park and Irvine, Calif., and is advertising 60 new positions.

"There's a constant drive to do better. It's great for the product and great for the team," Mitchell says. "He jokes that I'm Nice Nate and he's Bad Brendan. Say there's a product that comes before us. I'd say these five things aren't important. He'd disagree and say all five have to be done."

Members of the crew work long days and nights (often in flip-flops or stocking feet).

Falcone laughs as he recalls their diet for staying up all night at Quatrefoil: "A scoop of vanilla ice cream, grind the s*** out of some coffee, pour it on top and eat it, while pounding Cokes and Dr. Peppers all the time."

When Iribe left Quatrefoil all those years ago, he posted a note on Falcone's wall, where it remains today: *After four years and many sleepless nights, Brendan's saga ends. Not really. It's hard to get rid of me.* ■

AT THE SIGNING CELEBRATION IN SEPTEMBER 2014. (L-R) JAYANTH BANAVAR, MICHAEL ANTONOV, MARY ANN RANKIN, BRENDAN IRIBE, ELIZABETH IRIBE, WALLACE LOH.

COMPUTER SCIENCE RECEIVES $38.7 MILLION IN GIFTS

A record $31 million gift from a former University of Maryland student will help create a new home for the Department of Computer Science—and raise its stature as a global leader in virtual reality, robotics, computer vision and immersive science.

The Brendan Iribe Center for Computer Science and Innovation, named for the Oculus VR co-founder and CEO who made the largest single gift in university history, will be a place where students and faculty members from across campus can come together to learn, create and discover.

Oculus Co-founder and Chief Software Architect Michael Antonov, B.S. '03, computer science, who has worked alongside Iribe since their days at UMD, is giving $4 million for the building project and scholarships, and Iribe's mother, Elizabeth, is contributing $3 million for two endowed professorships in computer science. Thirty-two computer science faculty members have personally committed over $733,000 to help fund the building.

"The innovation and entrepreneurship that will be sparked in the Iribe Center will be an economic engine for our state and nation," says Jayanth Banavar, dean of the College of Computer, Mathematical, and Natural Sciences.

Iribe, who studied at UMD in 1997-98 before beginning his career as a serial entrepreneur, first suggested creating—and funding—the building only 10 days after Facebook announced in March that it would acquire Oculus for approximately $2 billion.

"I'm making this investment now because it gives me the opportunity to participate alongside the students and help them in any way I can to create amazing things," says Iribe. "I don't want to just be a name on a building. I want to be someone who continues to show up on campus and inspires student exploration and entrepreneurship for years to come."

The new facility, which will be located adjacent to the Computer Science Instructional Center at the main entrance to campus, will emphasize communal meeting spaces, community areas and hands-on learning. It will include "maker spaces" and "hacker spaces" with equipment and tools for students and faculty across campus to collaborate, experiment and bring their ideas to life.

"Virtual reality enables your imagination to go wild," says Antonov. "Having a facility at the University of Maryland that encourages and sparks this type of creativity will provide a unique experience for students."

Students will have the opportunity to take courses in classrooms designed specifically for interactive and active learning. The building will also include specialized labs to support the expansion of research in areas such as virtual and augmented reality, computer vision, robotics and big data.

New research in these areas will enhance ongoing projects, like the "augmentarium" Amitabh Varshney, computer science professor and director of the university's Institute for Advanced Computer Studies (UMIACS), is constructing with support from the National Science Foundation. The space will feature interactive

"I DON'T WANT TO JUST BE A NAME ON A BUILDING. I WANT TO BE SOMEONE WHO CONTINUES TO SHOW UP ON CAMPUS AND INSPIRES STUDENT EXPLORATION AND ENTREPRENEURSHIP FOR YEARS TO COME."

-BRENDAN IRIBE

Photo by Mike Morgan

projection displays, head-mounted displays, programmable robotic mounts and high-speed computing clusters that researchers will use to visualize large and complex data for a range of applications, including image-guided surgical interventions.

Computer Science Professor Ramani Duraiswami, who also has an appointment in UMIACS, is applying his research on how humans understand sound to create virtual reality environments in which users feel immersed in the sounds of another world. His College Park, Md.-based company VisiSonics recently announced that Oculus licensed its RealSpace3D audio technology to create high-fidelity virtual reality experiences for the Oculus Rift headset.

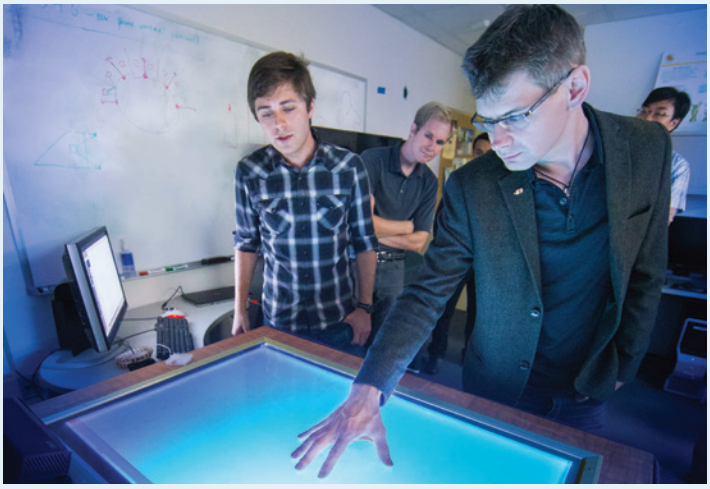
"Placing the University of Maryland at the center of virtual reality research with ties directly to Oculus will be amazing for the faculty and students who will be part of this new industry that will have a huge impact on the world," says Iribe.

While virtual reality technology has its roots in video gaming, Iribe sees future virtual reality applications in medicine, travel, history, art, sports and more. In the new building, students—with majors ranging from engineering and art to business and behavioral science—and local community members will be invited to attend courses and events and use its space to pursue projects that could change the world.

The Iribe Center will help centralize computer science and UMIACS faculty members who are currently spread out among four buildings on campus, with A.V. Williams (a building designed in 1987 as generic office space) serving as home base. The new facility will also support the growing computer science department, where undergraduate enrollment has expanded from nearly 800 majors in 2009 to almost 1,400 in 2013, with more than 200 students pursuing graduate degrees. Recently, the 40-year-old department was named No. 17 in the Academic Ranking of World Universities and No. 15 in U.S. News & World Report's rankings of graduate programs.

"Two of my goals in giving this donation are to raise the position of the university and attract many more top computer science students and faculty members," says Iribe. "Right now, we're top 15, but top 5 is better and No. 1 is best!"

Computer science students will also benefit from the new scholarships Iribe and Antonov are creating. Iribe pledged $1 million of his donation and Antonov gave $500,000 of his toward scholarships, which include a fund in memory of their longtime business partner Andrew Reisse, B.S. '01, computer science, who passed away in 2013.



MICHAEL ANTONOV (RIGHT) VISITS RESEARCH LABS TO LEARN ABOUT COMPUTER SCIENCE FACULTY MEMBER AND STUDENT PROJECTS.

"I BELIEVE IN PUBLIC EDUCATION, AND I'M SO GLAD BRENDAN AND I ARE INVESTING IN THE STATE OF MARYLAND'S FLAGSHIP INSTITUTION."
-ELIZABETH IRIBE

"The gift began after a tragedy and will end in a living memorial," said UMD President Wallace Loh. "It demonstrates the impact of friendship, teamwork and family—qualities that ultimately benefit our students and faculty."

Elizabeth Iribe's named chairs will support the department chair of computer science and a yet-to-be-recruited faculty member who inspires students and conducts innovative research.

"I believe in public education, and I'm so glad Brendan and I are investing in the state of Maryland's flagship institution," says Elizabeth Iribe.

"The gifts from Brendan, Michael and Liz will completely transform computer science at Maryland. The impact will be felt by our students, faculty, staff and the state for decades to come," says Samir Khuller, chair of the Department of Computer Science. "They will help us achieve greatness, move into new research areas and provide an unparalleled experience for students."

Computer Science Professor Emeritus Bill Pugh, who is helping with the building's fund-raising effort and kicking in $500,000 of his own money, says more engagement from alumni and state officials is needed to fully realize a wonderful future for computer science at Maryland.

"The Iribe Center will significantly improve the research and educational impact of the computer science department and make us the top-ranked maker/hacker university in the world. The leadership gifts from Brendan and Michael and the important commitment of the faculty are a great start, but to fully realize that vision, we need to raise an additional $15 million from donors and $100 million from the state," says Pugh. ■

–ABBY ROBINSON

Faculty Donors *to the* Brendan Iribe Center *for* Computer Science *and* Innovation

Ashok Agrawala
J. Yiannis Aloimonos
Benjamin Bederson
W. Rance Cleaveland
Larry Davis
Amol Deshpande
Ramani Duraiswami
Howard Elman
Jeffrey Foster
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Elaine Shi
Ben Shneiderman
Neil Spring
Aravind Srinivasan
Alan Sussman
Amitabh Varshney

Photo by John T. Consoli

Tipping Point TO Turning Point

PATRIZIA BARONE (RIGHT) WITH HER SISTER, SAPIENZA BARONE, B.A. '77, ENGLISH, AND THE INFAMOUS TRUCK.

"I owe my education to a thief… sort of," says Patrizia Barone, B.S. '78, chemistry.

Born in Italy, Barone and her family immigrated to Uruguay when she was young, and they made a living selling fruits and vegetables. The middle of three children, Barone helped with the family business, where she developed sales skills at an early age. When Barone was 10, someone stole the family's truck, which was used to transport the produce. At the time, Uruguay was going through political unrest and tough economic times, and members of her extended family had already moved to the U.S. "The theft of the truck was the tipping point for my family to decide to leave Uruguay a few years later," Barone says.

The Barones packed up and moved to the U.S. in 1970, a move Barone says "created the opportunity for my success." She eventually won a scholarship to attend the University of Maryland and later earned her Ph.D. in inorganic chemistry at Georgetown University.

She credits the support of her parents and others for helping her chart a remarkable path to several high-level corporate positions, logging more than 5 million air miles in the process. "My parents had to cut their educations short in Italy during World War II," she says, "so they made sure their kids received an education, even if it was a struggle for them at times."

Barone's background helped her secure a job at Colgate-Palmolive after receiving her doctorate. Fluent in Italian, Barone was hired to develop detergent soaps for the Philippines, a position that required working closely with the research and development (R&D) laboratory in Italy. Her product development skills were honed in her next position with Bayer's consumer products division in Chicago.

By age 32, Barone was named vice president of R&D at Reckitt Benckiser, where she led the North American R&D laboratory. Later, she moved to Sydney, Australia, to direct all product development activities for Australia, New Zealand, South and East Asia, Africa, and the Middle East. In 2000, she returned to the U.S. to lead the company's global regulatory affairs organization.

In 2009, Barone joined Unilever and now represents the company on the board of the Alliance for Consumer Education and supports the Alliance's program to prevent inhalant abuse. As Unilever's regional vice president of regulatory affairs for North America and global foods and refreshment, Barone is the one helping others work toward success.

Well aware of the support she received throughout her career, Barone believes in giving back. She currently serves on the Department of Chemistry and Biochemistry's Committee of Distinguished Advisors and chairs the advisory board of the Joint Institute for Food Safety and Applied Nutrition (JIFSAN).

In addition, she has created two scholarships in honor of her parents' commitment to education: The Francesco Barone Scholarship for chemistry students in the College of Computer, Mathematical, and Natural Sciences, and the Rosina Barone JIFSAN Educational Fund in the College of Agriculture and Natural Resources.

"I was fortunate to receive scholarships and work-study employment during my years at Maryland," Barone says. "That support allowed me to complete my education and was the springboard for my successful business career. I really want to pay it forward and give back to the University of Maryland to help students achieve their dreams."

She adds, "One of the scholarship students found me on Facebook to tell me she just got her medical degree. She said now that she's graduated, she can help others. That's the most powerful thing." ■ *–ELLEN TERNES*

PATRIZIA BARONE STANDS NEXT TO A MARYLAND DAY-THEMED TERRAPIN SCULPTURE, WHICH SHE DONATED TO THE COLLEGE. THE TERRAPIN IS ON DISPLAY IN SYMONS HALL.

INSPIRED BY PATRIZIA?

JOIN PATRIZIA BARONE IN MAKING A DIFFERENCE IN THE LIFE OF A STUDENT. CONTACT ANDREA MORRIS AT 301.405.8296 OR AEMORRIS@UMD.EDU FOR MORE INFORMATION.

Photos courtesy of Patrizia Barone

THE Mechanicks OF Mentoring

JEFFREY MECHANICK

As a first-year medical student at the Mount Sinai Icahn School of Medicine in Manhattan, Aaron Weiss hit the academic jackpot when nationally recognized endocrinologist Jeffrey Mechanick, B.S. '81, zoology; M.D. '85, Mount Sinai, took Weiss under his wing to mentor him.

Now a resident in cardiothoracic surgery, Weiss says, "Dr. Mechanick has been the most influential person I've encountered in getting to where I am now. He gave me so many opportunities to do so much."

As director of metabolic support and clinical professor of medicine at Mount Sinai, author of six books and more than 200 journal articles, the former president of the American Association of Clinical Endocrinologists, and a member of the President's Council on Fitness, Sports, and Nutrition Science Board, Mechanick is the perfect mentor.

Mentoring students like Weiss, who shares his intense drive to learn, has brought Mechanick full circle to his own experiences as an undergraduate at the University of Maryland. When Mechanick was a student, he took risks when it came to what and how he wanted to learn. In his sophomore year as a pre-med student, when getting A's was a priority, Mechanick took a Ph.D. level course in the philosophy of mathematics without completing any of the prerequisites. Despite warnings by the professor—who thought he was in the class by mistake—he earned an A. "I go as fast as I can and circumvent the rules to learn as much as I can," says Mechanick. Later, during his junior and senior years, Mechanick conducted endocrinology research at the University of Maryland School of Medicine that resulted in a paper published in the Journal of Neural Transmission.

He credits mentoring by UMD professors, including biology faculty members William J. Higgins and Howard Brinkley, as one of the most important factors in fueling his fire to learn. "The University of Maryland was a place that said, 'Here's someone who wants to learn, let's help.' There was a strong belief in mentorship to advocate and facilitate learning," recalls Mechanick.

Even before they reconnected several years ago, Higgins remembered Mechanick clearly. "He's one of the few undergrads whose conversations about science I still remember," Higgins says. "Jeff has a good time intellectually, and he's so enthusiastic about everything."

Mechanick remains enthusiastic about UMD. He serves on the college's Board of Visitors, is active with the Joint Quantum Institute and supports the William J. Higgins Distinguished Scholar-Teacher Fund that honors his mentor. "I look to enrich people," Mechanick says. "I think I can speak for many alumni that we want to be engaged."

In his current role, Mechanick says, "I characterize much of my career here at Mt. Sinai as finding mentees. I learned many of these mentoring skills as a mentee at Maryland, and so the cycle goes on."

That cycle will likely continue for another generation, says Weiss. "When I have more experience, I would be thrilled to do half as much for someone as Dr. Mechanick has done for me." ■ *–ELLEN TERNES*

Mechanick photo by Loretta Kuo / Stethoscope designed by Theresa Berens from the Noun Project

SUJAL PATEL (ABOVE CENTER AND INSET) SPEAKS TO ALUMNI IN SEATTLE.

Terps Take Seattle

Overlooking beautiful Lake Union, nearly 100 University of Maryland alumni and guests enjoyed the scenery and the conversation at Seattle's Museum of History & Industry on June 12. The networking reception was co-hosted by the College of Computer, Mathematical, and Natural Sciences (CMNS) and the Robert H. Smith School of Business.

Guest speaker Sujal Patel, B.S. '96, computer science, shared his entrepreneurial experiences as founder of Isilon Systems, a company that offered clustered storage systems to address the needs of storing, managing and accessing digital content and other unstructured data. Patel guided Isilon's acquisition by EMC in 2010 for over $2 billion and served as the president of EMC's Isilon Storage Division until 2012. Drawing on lessons learned throughout his career, Patel urged fellow alumni to be forward thinking and anticipate where their industries are headed, rather than be satisfied with where they are now.

One of Patel's mentors, Richard Gerber, traveled from Europe to attend the reception. Gerber, a computer science professor at UMD from 1991 to 2001, taught Patel in a special topics course on video streaming methods—long before video streaming was a reality. During the reception, CMNS Dean Jayanth Banavar recognized Gerber for his lifelong dedication to students.

William Pugh was also recognized by Banavar for his contributions to the university. A computer science professor at UMD for 23 years, Pugh focused on recognizing and building on students' individual strengths and learning styles to elicit their best work. After retiring from UMD in 2012, he went on to lead an effort to create a UMD program called Computer Science Education for Tomorrow. ■

$1.2 Million to Broaden Undergraduate Science Education Experiences

In May, the Howard Hughes Medical Institute awarded the College of Computer, Mathematical, and Natural Sciences a five-year, $1.2 million grant for undergraduate science education. The college will use the grant to establish a new living-learning program for students in the biological and chemical sciences, create opportunities for students to engage in biological and chemical sciences research during their first semesters, and support mentoring programs for students.

Representing the sixth such award that the University of Maryland has received since 1992, the new grant will help the university meet the rising demand from faculty and students for high-quality, innovative, cross-disciplinary experiences in education and research.

"Our existing programs provide a solid foundation on which to build these new initiatives, which focus on supporting and retaining students who may be at risk of abandoning careers in the biological and chemical sciences," said Katerina Thompson, director of the college's undergraduate research and internship programs.

The new living-learning program will include a common residence hall with integrated academic support, community-building activities such as field trips to local research laboratories, co-enrollment in introductory science courses and early access to research opportunities. This new program will join five other college-sponsored living-learning programs—three in College Park Scholars and two in the Honors College. ■

Photos by Greg White

Faculty Named to Leadership Posts

WOLFGANG LOSERT

JONATHAN DINMAN

CHRISTOPHER JARZYNSKI

On July 1, the College of Computer, Mathematical, and Natural Sciences announced three new appointments.

Wolfgang Losert was named the college's interim associate dean for research. A physics professor with appointments in the Institute for Physical Science and Technology (IPST) and the Institute for Research in Electronics and Applied Physics, Losert's research focuses on discovering emergent dynamic properties of complex systems at the interface of physics and biology, with a special emphasis on cancer biology. He is the co-founder and leader of the Partnership for Cancer Technology, which provides faculty and graduate students the opportunity to tackle pressing problems in cancer research in collaboration with National Cancer Institute experts.

Jonathan Dinman was appointed interim chair of the Department of Cell Biology and Molecular Genetics. He joined the university in 2002 as an associate professor in cell biology and molecular genetics and was promoted to full professor in 2008. He has pursued research on virology, ribosome structure and function relationships, and regulation of gene expression.

Christopher Jarzynski, Distinguished University Professor in chemistry and biochemistry, has been named director of IPST. Jarzynski joined UMD in 2006. His research focuses on statistical mechanics at the molecular level, specifically the foundations of non-equilibrium thermodynamics, the application of statistical mechanics to problems of biophysical interest, the analysis of artificial molecular machines, and the development of efficient numerical schemes for estimating thermodynamic properties of complex systems. ■

Commencement 2014

AT THE COLLEGE'S SPRING 2014 COMMENCEMENT, MARCIA MCNUTT, EDITOR-IN-CHIEF OF SCIENCE MAGAZINE, ENCOURAGED GRADUATES TO AIM HIGH AND PURSUE THEIR CAREERS WITH PASSION. DRAWING ON HER OWN POST-COLLEGE EXPERIENCES, SHE SPOKE ABOUT WARNING THE PUBLIC ABOUT NATURAL DISASTERS AND HELPING CONTAIN THE DEEPWATER HORIZON OIL SPILL.

MCNUTT CONGRATULATED THE GRADUATES, NOTING, "MY WISH TO YOU, CLASS OF 2014, IS THAT YOU ALL FIND YOUR WAY TO SOMETHING THAT REALLY AND TRULY MAKES A DIFFERENCE, AND IN THE FUTURE, YOUR RIVALS WILL NOT SAY 'FEAR THE TURTLE', BUT 'THANK THE TURTLE'."

WATCH A RECORDING OF THE EVENT AT TER.PS/CMNSGRAD14.

Losert and Dinman photos by John T. Consoli / Jarzynski photo by Andrew Snadecki / McNutt photo by GradImages

FACULTY & STAFF HIGHLIGHTS

Faculty were recognized for their contributions to the university at the Faculty and Staff Convocation held on Oct. 7, 2014.

- *President's Medal*
  Ann Wylie, geology
- *Distinguished University Professors*
  James Drake, physics
  Sylvester James Gates, physics
  Christopher Jarzynski, chemistry and biochemistry
  Dianne O'Leary, computer science
- *Distinguished Scholar-Teachers*
  Sarah Eno, physics
  Alan Kaufman, geology
- *Kirwan Undergraduate Education Award*
  Steven Rolston, physics

Millard Alexander, chemistry and biochemistry, was elected to membership in the International Academy of Quantum Molecular Science, which promotes research and international collaboration related to the application of quantum theory to chemistry and chemical physics.

Sankar Das Sarma, physics, **Najib El-Sayed**, cell biology and molecular genetics, **Mihai Pop**, computer science, and **Jeremy Selengut**, University of Maryland Institute for Advanced Computer Studies, were included on Thomson Reuters' recently launched list of Highly Cited Researchers, a compilation of influential names in science. These researchers earned the distinction by writing the greatest numbers of reports officially designated by Essential Science Indicators as Highly Cited Papers—ranking among the top 1 percent most cited for their subject field and year of publication—between 2002 and 2012.

Eric Haag, biology, published a paper in the journal PLOS Biology about how cross-species mating of worms leads to sterility and death. Major media outlets covering the work included the Huffington Post, Los Angeles Times, National Geographic, New Scientist, Popular Science, Science News, The Verge, The Washington Post and Wired (UK).

Michael Hicks and **Elaine Shi**, computer science, and graduate student Chang Liu won the National Security Agency's 2014 Best Scientific Cybersecurity Paper Competition. Their paper was titled "Memory Trace Oblivious Program Execution" and had been presented at the 2013 IEEE Computer Security Foundations Symposium.

David Inouye, biology, was appointed to the National Academy of Sciences' Public Interfaces of the Life Sciences roundtable. Inouye also will be a lead author of an assessment of pollinators, pollination and food production for the United Nations' new Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.

Melissa Kenney and **Richard Moss**, Earth System Science Interdisciplinary Center, contributed to the third National Climate Assessment released in early May. Kenney, who is also a lead principal investigator of the U.S. Global Change Research Program's National Climate Indicator System, was a lead author of the assessment's decision support chapter. Moss, who is also a senior staff scientist with the Pacific Northwest National Laboratory's Joint Global Change Research Institute, was a convening lead author for the same chapter and prepared scenarios and other guidance materials for the authors.

Zhanqing Li, atmospheric and oceanic science, was elected fellow of the American Geophysical Union (AGU)—an honor conferred on less than 0.1 percent of all AGU members in any given year. Li was also awarded the 2014 AGU Atmospheric Science Section Kaufman Award for "broad influence in atmospheric science through exceptional creativity, inspiration of younger scientists, mentoring, international collaborations and unselfish cooperation in research."

Howard Milchberg, physics and electrical and computer engineering, published a paper in the journal Optica about optical waveguides he created. Major media outlets covering the work included the Australian Broadcasting Corporation, Canadian Broadcasting Corporation, Discovery News, Geek, Gizmag, Gizmodo, New Scientist, Slashdot, Smithsonian and Wired (UK).

Richard Mushotsky, astronomy, and **Dheeraj Pasham**, Ph.D. '14, astronomy, published a paper in the journal Nature confirming the existence of an intermediate-mass black hole. Major media outlets covering the work included the Christian Science Monitor, Earth and Sky, Huffington Post, LiveScience, Science magazine, Space.com and Time.

Nick Schmerr, geology, was awarded the Doornbos Memorial Prize by the Committee on Studies of the Earth's Deep Interior at its biennial meeting in Japan in August. Awarded to a young scientist for outstanding work on Earth's deep interior, the prize is given in honor of the Dutch seismologist, Durk Doornbos.

Francesco Tombesi, astronomy, received the 2014 Astrophysics Science Division Peer Award from NASA's Goddard Space Flight Center, for "outstanding contributions in support of the ASTRO-H mission and to the understanding of ultrafast outflows in active galactic nuclei." ■

IN MEMORIAM

Irving Kipnis, chemistry and biochemistry, died August 4. Kipnis earned his Ph.D. in organic chemistry, directed the operations of the lower division laboratories and taught in the science in the evening program. In addition to training new instructors, interfacing with the Department of Environmental Safety and serving as a compliance officer, Kipnis was involved in departmental outreach programs such as the Maryland Science Olympiad, Chemathon and Outward Bound.

Thelma M. Williams, retired associate dean of undergraduate education for the College of Computer, Mathematical and Physical Sciences (CMPS), died June 26. Beginning in 1981 as assistant to the provost of the then Division of Mathematical, Physical Sciences and Engineering, and through her last eight years as CMPS associate dean for undergraduate education (1990-1998), Williams consistently provided strong leadership and positively influenced hundreds of individual students. Her primary operating principles set the tone, culture and reputation of the Office for Undergraduate Education: students come first, students will take responsibility for their academic experience and always encourage academic excellence. ■

ALUMNI HIGHLIGHTS

Mustafa Bilgic, Ph.D. '10, computer science, advisor Lise Getoor, received a National Science Foundation Faculty Early Career Development (CAREER) award for his project that focuses on how active learning can potentially minimize the cost, time and effort involved with annotating machine models. Bilgic is an assistant professor of computer science at the Illinois Institute of Technology.

Sujal Bista, Ph.D. '14, computer science, advisor Amitabh Varshney, was honored with a best paper award at the annual IEEE Conference on Scientific Visualization, held in Paris in November. Bista's paper on visualization of diffusion kurtosis imaging tensors for understanding the brain microstructure was one of 34 papers accepted for presentation out of 136 submissions.

David Chitwood, B.S. '72, mathematics; Ph.D. '80, botany, was named a fellow of the European Society of Nematologists. Chitwood is the research leader of the U.S. Department of Agriculture's Nematology Laboratory in Beltsville, Md.

Jacob Devlin, M.S. '09, computer science, advisor Bonnie Dorr, won the award for best long paper from the Association of Computational Linguistics for his co-authored paper titled "Fast and Robust Neural Network Joint Models for Statistical Machine Translation." Devlin is currently a natural language processing research scientist at BBN Technologies.

Rao Kambhampati, Ph.D. '89, computer science, advisor Jim Hendler, has been named president-elect of the Association for the Advancement of Artificial Intelligence. He will serve as president from 2016 to 2018. Kambhampati is professor of computer science and engineering at Arizona State University.

Amnon Lotem, Ph.D. '00, computer science, advisor Dana Nau, will receive the 2014 Gödel Prize for a co-authored paper titled "Optimal Aggregation Algorithms for Middleware," which introduced the powerful "threshold algorithm" that is widely used in applications and systems that demand optimal results for gathering multisourced information. The award, which recognizes outstanding papers in theoretical computer science, is presented by the European Association for Theoretical Computer Science and the Association for Computing Machinery's Special Interest Group on Algorithms and Computation Theory.

Tobin Marks, B.S. '66, chemistry, was awarded the 2014 Sir Geoffrey Wilkinson Award by the Royal Society of Chemistry for "his pioneering work in organometallic chemistry, particularly with regard to catalysis, as well as his work in materials chemistry from molecular sources." Marks is the Charles E. and Emma H. Morrison Professor of Chemistry, the Vladimir N. Ipatieff Professor of Catalytic Chemistry, and professor of materials science and engineering at Northwestern University.

Nathalie McOmber, B.S. '00, biological sciences, was named one of the nation's top 40 dentists under the age of 40 by Incisal Edge magazine. McOmber, who is an attending dentist at Monmouth Medical Center, is profiled on the cover page of the magazine's fall 2014 issue. Per Incisal Edge, the "profiles of the best next generation of dentists are nominated by industry experts from around the country, vetted by an independent panel and presented in a manner befitting the honor—as the rock stars of our field."

Forrest W. Nutter, B.S. '76, botany, received the 2014 Outstanding Teaching Award from Iowa State University's College of Agriculture and Life Sciences in recognition of his interactive software training programs for plant disease epidemiology and his numerous teaching publications. Nutter's software programs are currently being used in more than 80 universities and 25 countries.

Aaron Schulman, Ph.D. '13, computer science, advisor Neil Spring, was recognized with the 2013 Special Interest Group on Data Communication (SIGCOMM) doctoral dissertation award. His dissertation "provides the first observations of fundamental factors that limit the reliability of the Internet's critical last-mile infrastructure and presents improvements to mitigate the effects of these factors." Schulman received his award at the annual SIGCOMM conference in Chicago in August.

R. Brent Tully, Ph.D. '72, astronomy, advisor T. A. Matthews, was awarded the 2014 Gruber Foundation Cosmology Prize. This prize honors leading cosmologists, astronomers, astrophysicists and scientific philosophers for theoretical, analytical, conceptual or observational discoveries leading to advances in understanding the universe. Tully has been an astronomer at the University of Hawaii since 1975. ■

ALUMNI NOTES ARE WELCOME.

PLEASE SEND THEM TO ODYSSEY, CMNS DEAN'S OFFICE, UNIVERSITY OF MARYLAND, 2300 SYMONS HALL, COLLEGE PARK, MD 20742. SEND INFORMATION BY FAX TO 301.314.9949 OR BY EMAIL TO MKEARNEY@UMD.EDU.

STUDENT HIGHLIGHTS

Astronomy graduate students **Gabriele Betancourt** and **Krista Smith** won NASA Earth and Space Science Fellowships (NESSF). Nine NESSF fellowships in astrophysics were awarded nationwide in 2014.

Computer science graduate student **Vahid Liaghat** received a 2014 Google Ph.D. Fellowship in market algorithms. The fellowship program supports students in computer science or closely related fields and reflects the company's commitment to building strong relations with the global academic community.

Biochemistry undergraduate student **Roger Lin** was interviewed by The Baltimore Sun about his scheduled summer trip to Guatemala with the nonprofit program A Broader View. Lin planned to help at a medical center in Xela, the second largest Guatemalan city located in the Sierra Madres.

Michael Ralph, chemical and life science graduate student and Olathe East High School (Kansas) teacher, has been awarded the 2014 Outstanding Biology Teacher Award, sponsored by the National Association of Biology Teachers.

Undergraduate student **Claire Weber**, biological sciences and geography, received a U.S. Department of State Critical Language Scholarship. A member of the Gemstone Honors Program, she studied Urdu in India over the summer. ■

COLLEGE OF
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