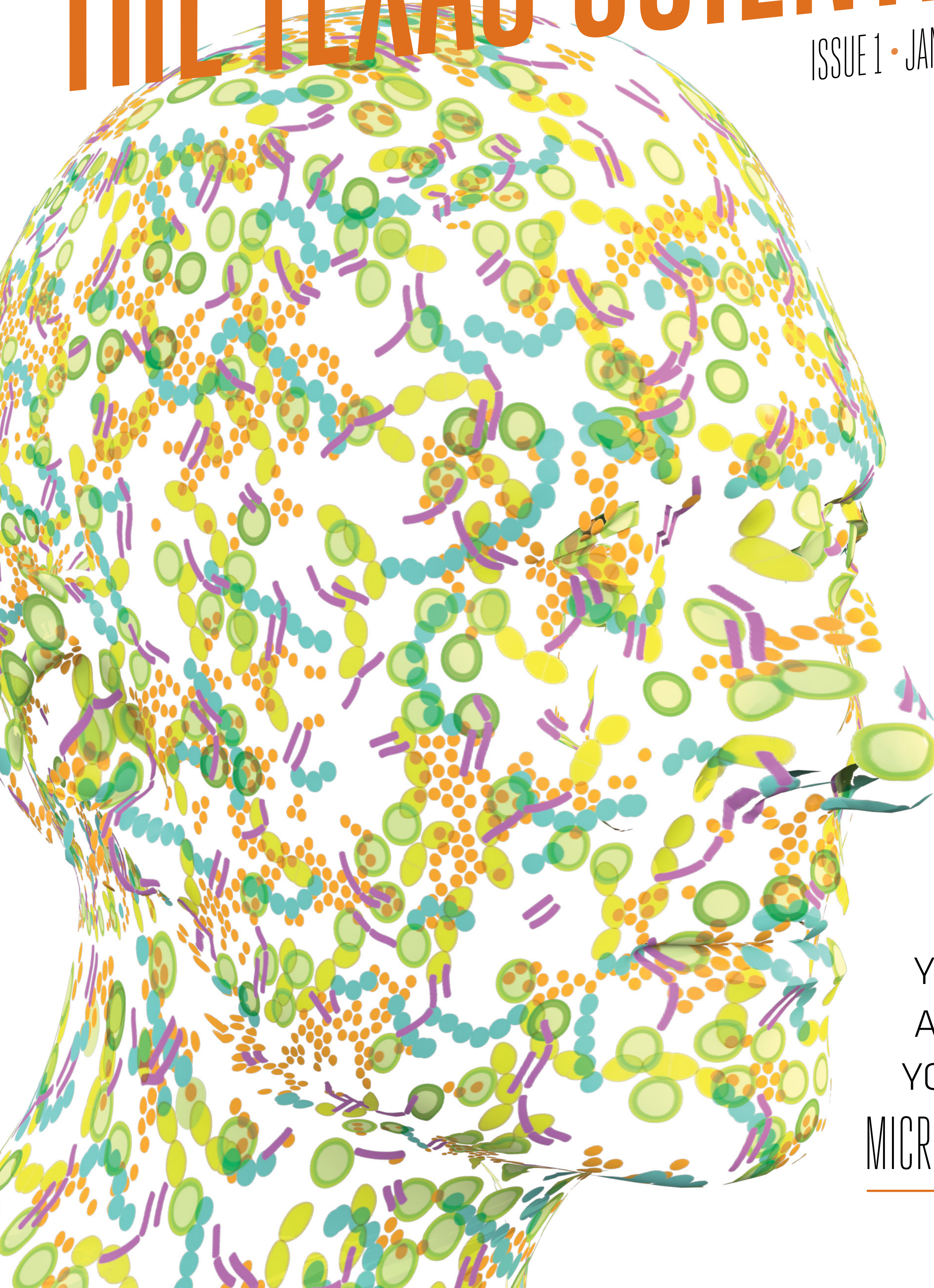
COLLEGE OF NATURAL SCIENCES • THE UNIVERSITY OF TEXAS AT AUSTIN

THE TEXAS SCIENTIST

ISSUE 1 • JANUARY 2014



YOU ARE YOUR MICROBIOME

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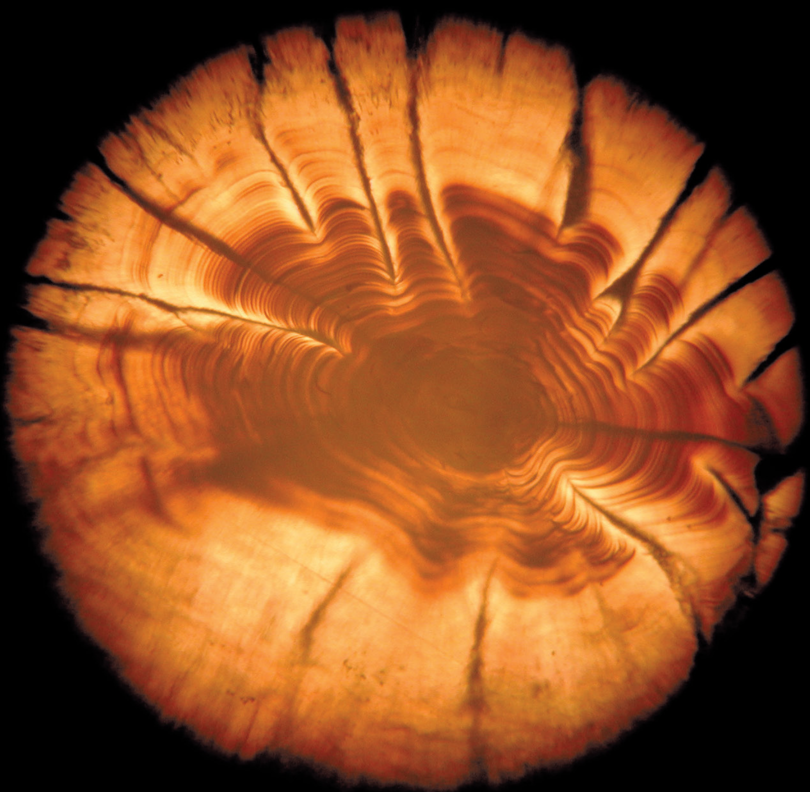
SNAP!



Ear Rings

This may look like a slice through a tree trunk, but it's actually part of a fish ear called an otolith. As with a tree, the rings mark growth periods for the fish. Marine scientist Ben Walther and his colleagues are using innovative methods to study the chemistry of the layers. The chemical signatures in each layer tell them things about the fish's life, such as where they lived. Walther and his graduate student John Mohan recently discovered that they can use otoliths to learn that fish grew in hypoxic (low oxygen) water, which is a common condition around coasts and is associated with run-off and pollution.

Photo provided by Benjamin Walther

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THE TEXAS SCIENTIST

A digest of the people and groundbreaking discoveries that make the College of Natural Sciences at The University of Texas at Austin one of the most amazing and significant places on Earth. #discoverystartshere

LETTER FROM THE DEAN

Dear Friends,

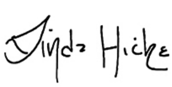
In your hands is the first issue of *The Texas Scientist*, a new publication that captures the spirit of discovery in the College of Natural Sciences. Take a moment to brush up on your science skills in the "Science Essentials" section, learn about advances in particle accelerators and the crazy ant invasion, and meet a couple of our outstanding students and one very cool alumna.

I also encourage you to check out our five-year roadmap at **cns.utexas.edu/strategic-plan**. Working on this plan with the faculty and staff across the college was one of the highlights of the past year for me. Another was participating in my first University of Texas commencement, and getting to know our exceptional alumni during visits to various cities across the nation where we highlighted the Freshman Research Initiative (**cns.utexas.edu/fri**).

While the College of Natural Sciences is a vast and varied group of people, we all share a love for discovery, and there is no place where this is happening in a more profound and exciting way than here. We are proud to wear our Texas Science shirts (if you'd like one too, visit: **cns.utexas.edu/store**).

If you are not already receiving our monthly e-newsletter, we do not have your email address. I encourage you to update your information with us at **cns.utexas.edu/alumni-friends** so that you can stay informed and connected to our community of teachers, learners, and discoverers. Natural Sciences is a community of game changers.

Discovery is everywhere—thank you for being a partner in our successful discoveries.



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The Texas Scientist is a publication of the College of Natural Sciences at The University of Texas at Austin.

Cover illustration by Jenna Luecke and Marianna Grenadier

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SCIENCE ESSENTIALS

Brush up on your science knowledge with these essential concepts

"There was a time when we thought we were special, that our sun was the only star with planets. Now, we know better."

1000+ Exoplanets Discovered

Bill Cochran, Research Professor of Astronomy

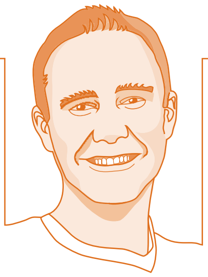
EXOPLANETS

There was a time when we thought we were special, that our sun was the only star with planets. Now, we know better. When I started in this field, we were just barely predicting the presence of exoplanets—planets that orbit other stars—and now we have proven the existence of more than 1000. The count is climbing every day.

As we looked at the sun and wondered why we have planets here, we compared the sun to other stars and were a little disappointed. We realized the sun is not special. The sun is just like all of the millions of other stars out there. There's absolutely nothing about our star that would lead to us to think there should be planets here and not elsewhere.

So when we started looking and finally figured out how to take the measurements and do the calculations correctly, we figured out that all of those other stars also have nice planetary systems around them. Current estimations say that every star has at least one planet orbiting around it.

It sort of puts our role in the universe into perspective—we really aren't that special. You know, this is one of the last places where humans can do exploration. Hundreds of years ago people would jump in a ship and find new worlds. Now I go up to my telescope.



Chris Sullivan, Associate Professor of Molecular Biosciences

RNA

RNA (ribonucleic acid) has come a long way in just a few short years. Once the ugly stepchild of the nucleic acids, it was thought to be a boring and simple intermediary that only decoded DNA into proteins. That's an important role, but only a sliver of its diverse set of functions.

RNA is a polymer composed of four different nucleotides connected by a sugar ribose backbone. It has very interesting structural and enzymatic functions, making it, in this way, similar to proteins. A large amount of what was once thought of as "junk DNA" is actually transcribed into different RNAs and used for a variety of functions.

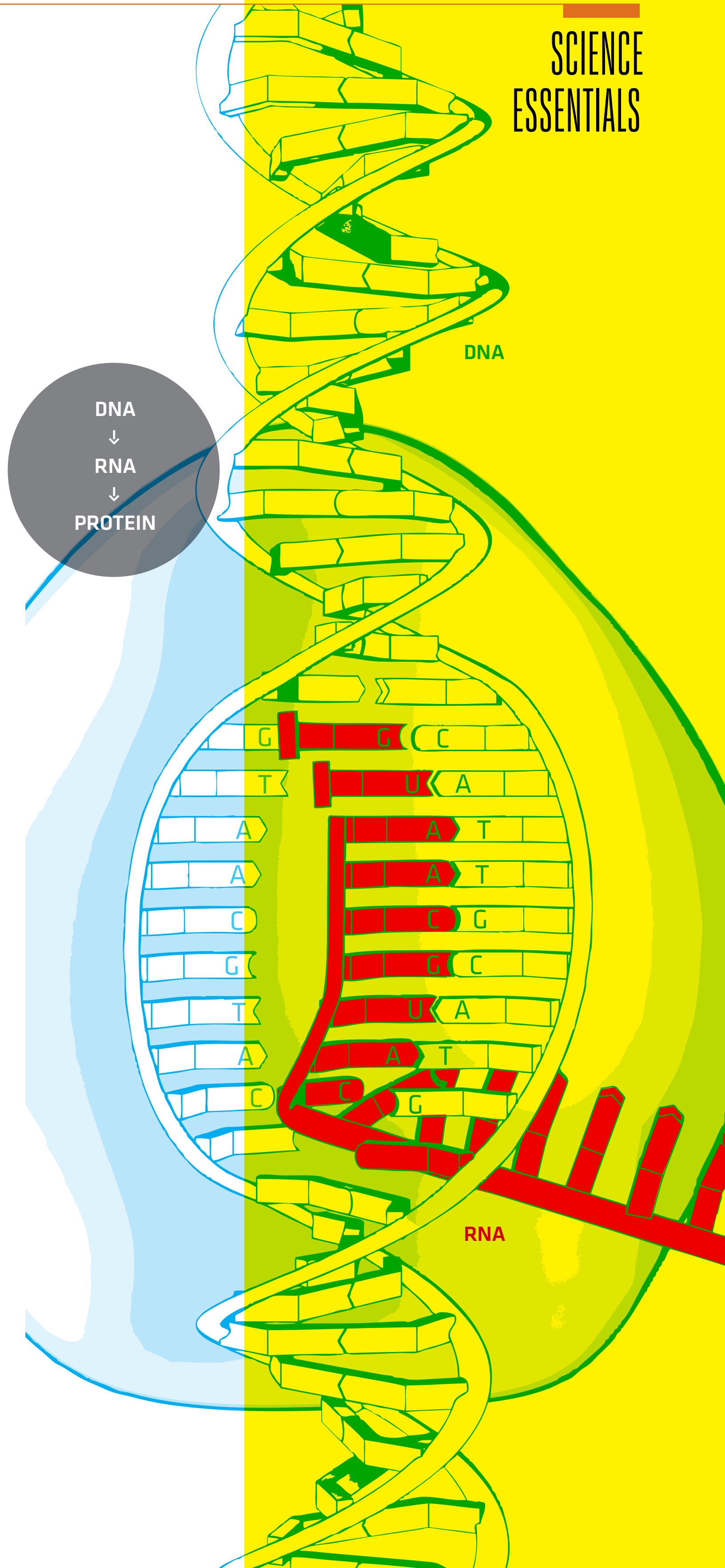
Regulatory RNAs, for example, seem to turn on or off certain genes. Versions of these RNAs can be synthesized and used to silence any gene, and this has exploded into a multi-billion dollar industry known as RNA interference.

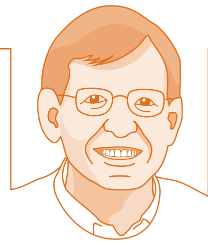
MicroRNAs, another type, serve as dimmer switches during gene expression, and are involved in almost all aspects of development and disease.

The vast functions of RNA have even led scientists to theorize that life started in an "RNA world" where RNA came first, because it can perform so many processes, and DNA evolved as the genetic material later.

Given the vastness of RNAs and their potential to unravel numerous mysteries of biology, collectively the RNAs have been referred to as the "dark matter" of the genome. We only understand the function of a minuscule fraction of them. Clearly, more discoveries await.

Sullivan is a fellow of the Lorene Morrow Kelley Endowed Faculty Fellowship Fund.





Mike Starbird, Professor of Mathematics

Learn the entire subject of calculus in 300 words.

CALCULUS

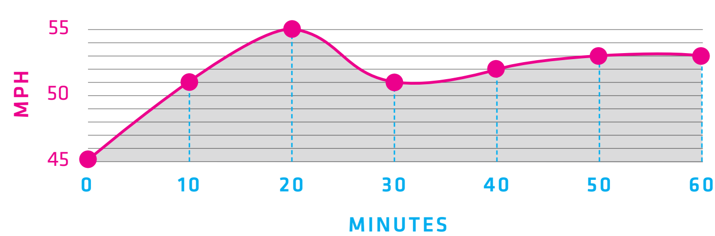
Most of the scientific and technological advances of the last 300 years depend on calculus, which is explained below in its entirety.

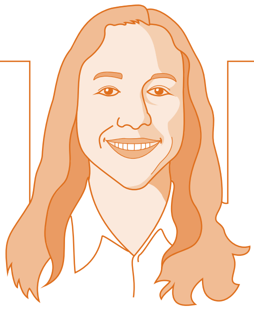
Imagine you are watching an avant-garde movie that shows only a car's perfectly precise odometer and clock as the car drives on a straight road. To occupy your mind, you figure out how to estimate the car's speed at any time. Subtracting odometer readings at two moments very close to each other and dividing by the elapsed time gives a good approximation of the car's speed. If you did this computation using moments increasingly close together, the final, limiting result is the instantaneous speed, which is shown by the speedometer. And you have just discovered the foremost analyzer of change—the derivative.

A second, hour-long movie shows only the precise speedometer and clock of the same car. To avoid death by boredom, you choose to compute how far the car must have driven during that hour. Since the speed varies, you divide the hour into tiny intervals of time, compute about how far the car went during each interval using the speedometer reading, and then add up the distances traveled in each interval to estimate the total distance traveled. Since the car actually varied its speed slightly even during an individual interval, an even finer approximation could be accomplished by taking even tinier increments of time. The resulting process carried to its logical conclusion would tell you the exact distance the car traveled during the hour. And you have just discovered the fundamental method of combining pieces to get the whole—the integral.

You now know two methods for computing the distance traveled. One: subtract the beginning from the ending odometer readings. Two: watch the speedometer and use the integral process. Since those two methods give the same result, you see the connection between the derivative and the integral, a connection known as the Fundamental Theorem of Calculus.

Therefore, except for 300 years of extensions, applications, and variations, you have learned the entire subject of calculus in 300 words.





Lauren Webb, Assistant Professor of Chemistry

SCANNING TUNNELING MICROSCOPY

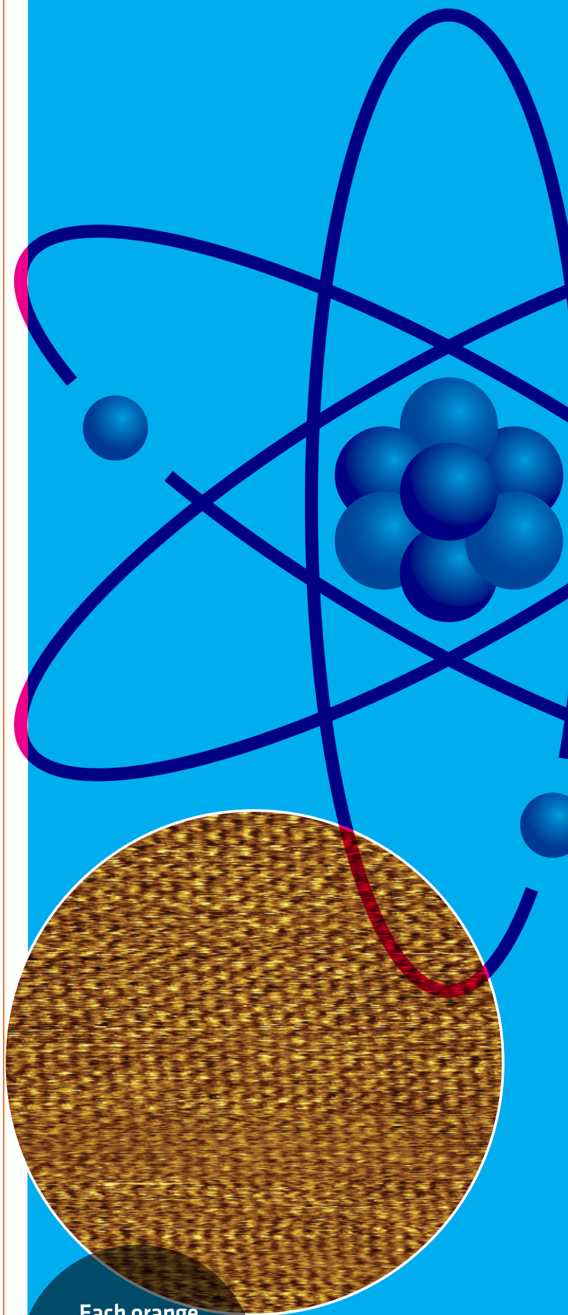
Our understanding of the structure of an atom hasn't changed since the early 20th century, but the way we visualize them certainly has. Scanning tunneling microscopy (STM) is now the norm, and it is a critical tool we use to visualize atoms and molecules and understand their structure.

We have all learned how electrons occupy regions of space around atoms, called "orbitals." However, it turns out these electrons sometimes move outside of their atomic orbitals. This happens in such a predictable manner that if you put two objects very close to each other they will begin to share electrons. In STM, we literally take an electrode and bring it very, very close to the surface of the material we're studying. We get it so close that the materials begin to share electrons, which in turn creates a current. This current is what we can measure.

The properties and function of a material are determined by its structure. We used to not be able to see the individual atoms and molecules of these materials, but now that we can with STM, the mysteries behind many materials have been solved. That's really what chemistry is all about right now—understanding how the properties of individual molecules combine and work together to create new properties in both artificial and biological materials.

Some, for example, have used the technique as a tool to pick up and drag individual atoms and molecules, literally organizing them. If we could do this on a large scale, it opens up all sorts of completely new fabrication and synthesis mechanisms.

> *"We have all learned how electrons occupy regions of space around atoms, called 'orbitals.' However, it turns out these electrons sometimes move outside of their atomic orbitals."*



Each orange dot in this STM image is a carbon atom

The Faculty Member

RUTH BUSKIRK

Distinguished Senior Lecturer in Biology. Interviewed by Steve Franklin.

You teach a number of difference courses here. Tell me about one of your favorites.
I teach a Costa Rican Maymester course called Land Use Issues in Rainforest Conservation, where we go to the rainforest in Costa Rica. We study the national parks, which are a public system, versus their private reserves. We look at management issues and then we also look at sustainable agriculture, because there are trade-offs. And then Costa Rica has ecotourism, which is booming. It's the number one economy now. We look at all the economics and the effect on the people there. The class is interdisciplinary, and I love the way everything fits together about it. It's pretty fun.

Do you still do any research?
I do some work on spiders in Costa Rica in the summers. Actually, I'm starting to research my students, to better understand how students learn and what helps them learn concepts in biology.

What are you most proud of doing at UT?
A lot of my accomplishments were started by other people. I'm very happy with the work David Laude [Senior Vice Provost for Enrollment] started, and Sacha Kopp [Associate

Dean of Undergraduate Education] is continuing, to get natural sciences students into small group environments. I think we're actually making a difference in having structures that get students to appreciate each other.

What do you do when you're not working to relax and recharge?
I like guitar music and all different kinds of music. The last couple of weekends I've gone to classical guitar performances here in Austin and it's pretty neat. But, most of the time I really like being with my family. My children are grown up now, but that's alright, I still like being with them.

What inspired you to go into biology?
I've always liked nature and being outdoors. We went on camping trips a lot when I was a kid. We went around and visited the national parks, so I know that made a difference. Also, my college, even though it was small, was very strong in biology, and I got to do undergraduate research. I was very fortunate. I like the way everything ties together in biology. That would be a general pattern for me. I like seeing how things fit together.

Buskirk is the holder of the Worthington Endowed Professorship for Ecology and Evolutionary Biology in Plan II.

Photo: Sarah Wilson

UNDER THE HOOD

by Steve Franklin

Take a peek under the hood in an organic chemistry teaching lab. Pictured are a few of the chemicals that students may encounter, or even synthesize, in the lab.

↓ BROMINE SOLUTION — $_{35}Br$

Bromine, an intermediate in making some organic chemicals, is also used in well drilling fluids and photographic film. Don't touch the stuff though; it hurts like the dickens if you get it on your skin!

↗ ACETONE — $(CH_3)_2CO$

The workhorse of the lab, acetone is used to clean glassware after an experiment and is also found in paint thinner and fingernail polish remover.

↗ IODINE CRYSTALS — $_{53}I$

Iodine, a vital biological nutrient, is used in the lab to help with Grignard reactions. Often employed as a disinfectant, it can also be used to purify water.

Photo: Alex Wang. Set up and guidance: Dr. Conrad Fjetland.

LUMINOL — $C_8H_7N_3O_2$

Familiar to fans of police procedurals, where it is used to detect trace amounts of blood at crime scenes, luminol gives off a blue glow by reacting with the iron found in hemoglobin. Alas, it's not infallible as it also reacts with other substances, like copper, bleach, horseradish, and fecal matter.

METHYL BENZOATE — $C_6H_5CO_2CH_3$

Methyl benzoate, which can be found in snapdragons, has a fruity odor and is used in perfumes and as a food additive.

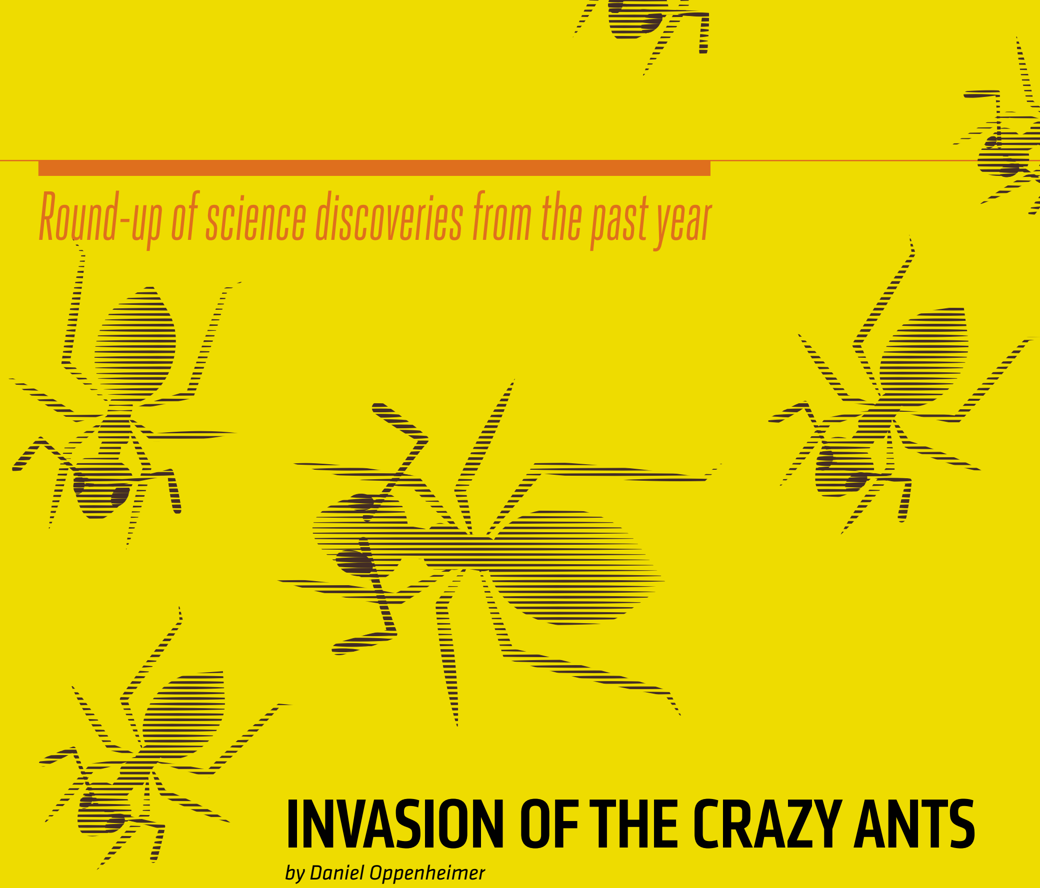
L-TARTARIC ACID — $C_4H_6O_6$

Louis Pasteur was the first to observe and separate crystals of the two stereoisomers, L-Tartaric acid and D-Tartaric acid, using just tweezers, a microscope, and a lot of patience. The acid occurs naturally in many plants and wine and is often used in baking and as a food additive.

AZO VIOLET — $C_{12}H_9N_3O_4$

This gorgeously colored compound is used as a dye and as a pH indicator.

Round-up of science discoveries from the past year



INVASION OF THE CRAZY ANTS

by Daniel Oppenheimer

Fire ants are no strangers to Southerners. For decades, they have been considered Pest Numero Uno for many a homeowner, rancher and farmer. They may have now met their match: the South American "crazy ant." These recent invaders to U.S. soils are beginning to displace fire ants across the southeast.

"When you talk to folks who live in the invaded areas, they tell you they want their fire ants back," said Ed LeBrun, a research associate with the Texas Invasive Species Program at the Brackenridge Field Laboratory. "Fire ants are in many ways very polite. They live in your yard. They form mounds and stay there, and they only interact with you if you step on their mound."

Crazy ants, by contrast, go everywhere. They invade homes, nest in crawl spaces and walls, become incredibly abundant, and damage electrical equipment. LeBrun recently found that crazy ants are reducing ant and arthropod diversity and abundance across a range of species. They may prove to have dramatic effects on the ecosystems of the region.

He said the ants' spread can be limited if people are careful not to transport them. Cutting down on transplantation of the ants could slow the spread by years or decades. And that extra time could give the ecosystems time to adapt, and researchers time to develop better control methods.

"We can really make a difference," he said, "but we need to be careful, and we need to know more."

Already found in 21 Texas counties, 20 counties in Florida, and in southern Mississippi and Louisiana.

ARCHITECTURE FOR BACTERIA

by Daniel Oppenheimer

Bacteria rarely act alone. They do their dirty business in giant colonies spread across the wet lining of your lungs or guts. Communities of multiple species can be found cohabitating or waging war against each other in one small abscess on your arm.

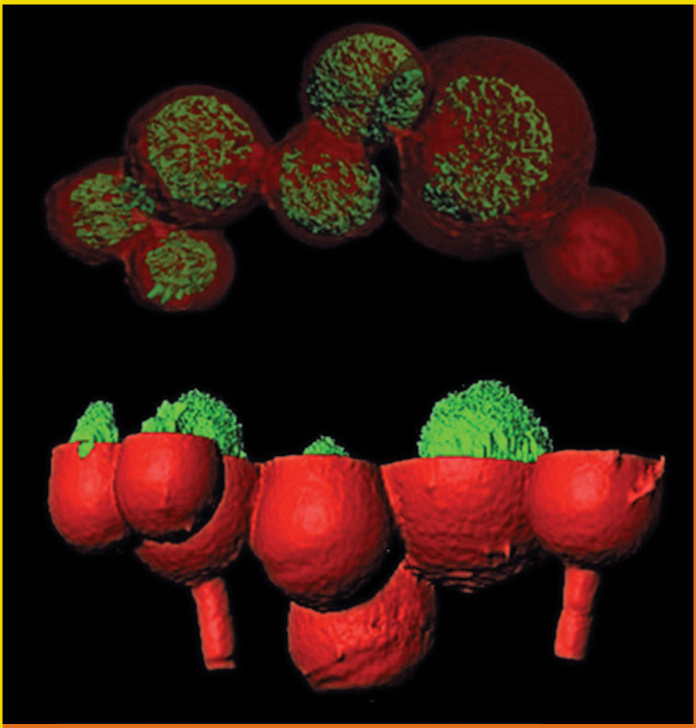
Studying how colonies of bacteria grow, change, compete and become resistant to antibiotics is becoming increasingly important, but has been difficult. College chemists and biologists are changing the game with an innovative method for building small gelatin cages for bacteria.

"We can define the spatial features on a size scale that's relevant to what a single bacterium feels and senses. We can also much more precisely simulate the kinds of complex bacterial ecologies that exist in actual infections, where there typically aren't just one but multiple species of bacteria interacting with each other," said Jodi Connell, a postdoctoral researcher in the Center for Systems and Synthetic Biology.

In a recent experiment, Connell, chemist Jason Shear and molecular biologist Marvin Whiteley demonstrated that a community of *Staphylococcus aureus*, which causes some skin infections, became more resistant to antibiotics when it was contained within a larger community of *Pseudomonas aeruginosa*, a bacteria involved in various diseases, including cystic fibrosis.

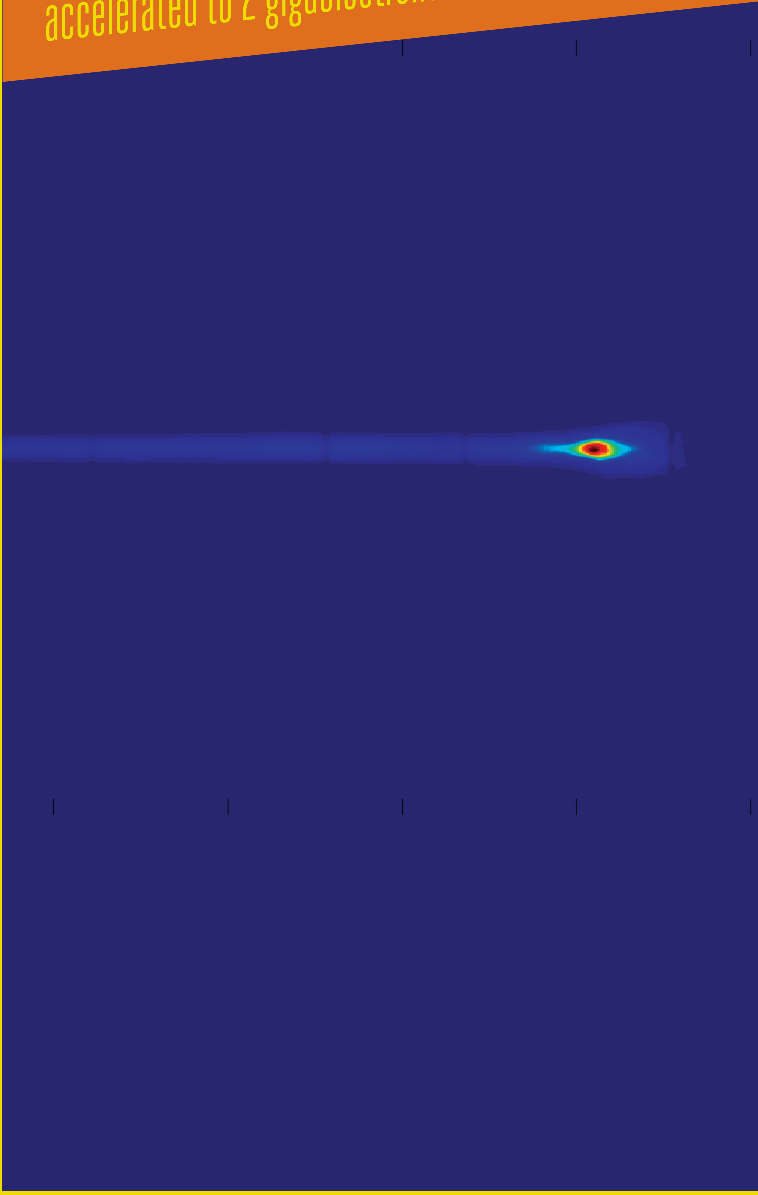
"These are really common bacteria that are often found together in infections, and it makes sense that they would have mechanisms to sense each other," said Shear. "What the technology allows us to do is put them in conversation with each other, in very precise ways, and see what happens. In this case the Staph sensed the Pseudomonas, and one result was that it became more resistant to the antibiotics."

Using a unique 3-D printing technique, researchers are building diversely shaped structures (in red) to house and study bacterial communities (in green). Credit: Jason Shear.



Jason Shear talks more about this ground-breaking technique in this video: youtu.be/dj1JuzCcYm4

It's a world record: half a billion electrons accelerated to 2 gigaelectronvolts.



The colored streak above was produced by magnetically bending the paths of 2 gigaelectron-volt (2 GeV) electrons emerging from an inch-long particle accelerator powered by the Texas Petawatt Laser in Robert L. Moore hall. The electrons' impact was recorded on a detector 8 feet away. The 2 GeV high energy electrons form the bright head of the streak, while the less energetic electrons form the diffuse tail. Image credit: Mike Downer.

PARTICLE POWER

by Daniel Oppenheimer

A small particle accelerator that fits on a table can generate energies and speeds previously reached only by major facilities that are hundreds of meters long and cost hundreds of millions of dollars to build.

"We have accelerated about half a billion electrons to 2 gigaelectronvolts over a distance of about one inch," said Mike Downer, professor of physics. "Until now that degree of energy and focus has required a conventional accelerator that stretches more than the length of two football fields. It's a downsizing of a factor of approximately 10,000."

The results mark a major milestone in the advance toward the day when accelerators are standard equipment in labs around the world. This would be transformative for chemists and biologists, who could use them to study the molecular basis of matter and life with atomic precision.

Lasers produced with the accelerator "will have the energy and brightness to enable us to see, for example, the atomic structure of single protein molecules in a living sample," said Downer.

QUENCHING THE THIRST OF MILLIONS

by Daniel Oppenheimer

Desalinating saltwater by the gallons with very little energy input could be the result of a new technique developed by college chemists. The method uses a small electrical field to remove salts from seawater and requires so little energy that it can run on a store-bought battery.

"The availability of water for drinking and crop irrigation is one of the most basic requirements for maintaining and improving human health," said Dick Crooks, the Robert A. Welch Chair in Chemistry. "The membrane-free method we've developed still needs to be refined and scaled up, but if we can succeed at that, then one day it might be possible to provide fresh water on a massive scale using a simple, even portable, system."

It holds particular promise for the water-stressed areas in which about a third of the planet's inhabitants live. Many of these regions have access to abundant seawater but not to the energy infrastructure or money necessary to desalt water using conventional technology. As a result, millions of deaths per year in these regions are attributed to water-related causes.

"People are dying because of a lack of freshwater," said Tony Frudakis, founder and CEO of Okeanos Technologies, a company that is working on commercial development of the technique. "They'll continue to do so until there is some kind of breakthrough, and that is what we are hoping our technology will represent."

Around 700 million people in 43 countries suffer from water scarcity today*

*from United Nations

The Graduate Student

RACHEL WOLF

Program: Cell and Molecular Biology. Interviewed by Steve Franklin.

"I enjoy tinkering at the bench. I enjoy that puzzle."

Tell us a little about your background.
I was born and raised in San Antonio. I went to a high school that was at the time in the poorest school district in Texas. There was a lot of racism, especially in the 70s, where you still had drippings over from the civil rights movement. I had teachers saying, "You can't make As because you're Mexican." I went into teaching and after a few years, I still wanted to do science, and decided to go back to night school at UTSA for a master's degree in marine biology. I was able to incorporate a lot of that into my classroom, and it made my teaching better. After teaching for a while, I started hearing more and more about molecular biology, and I wanted to know that. When I retired from teaching, I was finishing a master's degree in microbiology from UT Health Science Center in San Antonio. That's what made it easier for me to make the transition to UT Austin to graduate school.

What are you researching now?
Right now I am very happy to say I'm in Alan Lambowitz's lab. I look at splicing factors that help splice out introns in yeast mitochondria. I hope to be able to help us understand why higher eukaryotes, such as humans, don't have these introns. I enjoy tinkering at the bench. I enjoy that puzzle.

What do you do when you're not at school or the lab to relax and destress?
Well, you know I'm a graduate student, so I don't have much free time! But I do enjoy puzzles, like crosswords. I like walking and trying to find little tiny wild spaces where I can just get back in touch with nature.

Are there any other challenges or insights that you'd like to share?
Being Hispanic was definitely something that was a bit of an obstacle to overcome, just because of people's prejudice about it. I'm sure it stems from the poverty. But the second obstacle was being female. When I was growing up, women just didn't become scientists. You became a teacher, or a secretary, or a nurse. So, I'm really pleased to see that this has completely changed. Biology labs across the country are around 50 percent female.

Wolf received graduate fellowship support from the Mr. and Mrs. A. Frank Smith, Jr. Regents Chair in Molecular Biology.

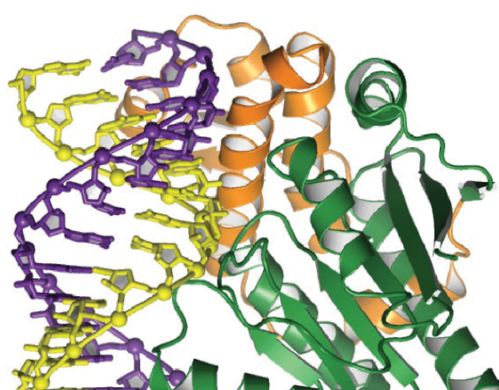


Photo: Sarah Wilson

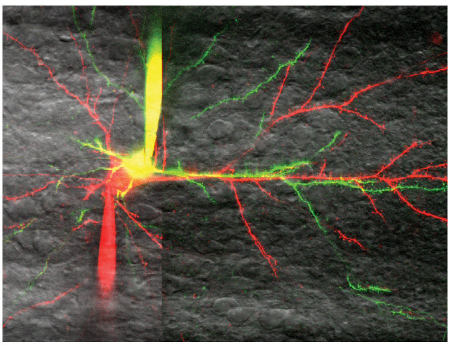
Beautiful images from labs around campus

A mouse embryonic skeleton, with bone stained Alizarin Red and cartilage stained Alcian Blue. Credit: Jacqueline Norrie, graduate student.

MASON HANKAMER

Majors: Neuroscience and Jazz Performance. Interviewed by Kaine Korzekwa.

So what do you like about neuroscience?
There is so much that we don't know about the brain. There is just so much to figure out and who knows what we can do with it once we know how it can be applied.



What is your history with the Longhorn Band?
I joined the Longhorn Band to march my freshman year and have been in it every year since. Although I'm a jazz bass major, I play the tuba in LHB, and have been a section leader for the past two years. It's such a great organization with amazing people.

"I like playing bass instruments because they produce a dark blue color to me. When I compose, it's like I'm painting a picture."

And how did you realize you wanted to add jazz performance as a major?
I've always really loved music. Doing neuroscience by itself just felt like there was an empty hole, but at the same time, if I were just to do music there would be this entire gap where my academic thinking was missing.

How do you think the two majors come together for you personally?
I have what's called color synesthesia, where I see music in colors. Certain sounds and instruments have different colors. For example, a song could be deep purple with sharp streaks of orange. I like playing bass instruments because they produce a dark blue color to me. When I compose, it's like I'm painting a picture. I don't actually see them physically; it's more the aura of the color, which is difficult to explain. What really links the two is that we studied the condition once in a neuroscience class. It was really neat to actually learn and understand why I experience this.

What are some ways you think music and the brain are connected?
I am always thinking about music. Just humming a song in my head during class makes me ask so many questions. How and why do songs get stuck in your head? How and why does this song make me feel this way? I think it's amazing how music completely inundates our entire lives. Take a look at ACL [Austin City Limits Music Festival]. Walk across campus and see everyone with their headphones. It's a weird force that controls a large portion of our lives whether we think about it or not. There has kind of been this cultural phenomenon created at the intersection of music and the brain.

Since 2012, Hankamer has been a recipient of the Willie Nelson Endowed Presidential Scholarship.

Photo: Sarah Wilson

Bill & Melinda Gates Computer Science Complex and Dell Computer Science Hall

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Exterior Building Photo: Paul Finkel. Interior Photos: Alex Wang.

March 2013 marked the grand opening of the Bill & Melinda Gates Computer Science Complex and Dell Computer Science Hall, a fantastic new building complex for the college. 1. The complex from Speedway. 2. Bill Gates speaking with Bill Powers during a lecture attended by computer science students and faculty. 3. Computer Science Professor J Strother Moore, President Bill Powers, Bill Gates, Dean Linda Hicke, Zachary Dell, Janet Mountain, and Computer Science Chairman Bruce Porter at the ribbon-cutting ceremony. 4. Exterior sign. 5. A Sol LeWitt painting graces a hallway in the new complex. 6. A group study lounge. 7. The wood-panneled atrium is a dynamic, central gathering space.

The Alumna

DONNA NELSON (Ph.D. '79)

Chemistry Professor, University of Oklahoma. Science Advisor, "Breaking Bad." Interviewed by Jessica Hascall.

"I got my Ph.D. with Michael Dewar at UT Austin, and he was a fabulous person and very inspirational."

Dr. Michael Dewar

Do you think TV shows like "Breaking Bad" have had a positive impact on science?
Oh yes, absolutely! There is so much discussion about the show. There are blogs written about it in which kids are arguing over which science is correct...that means they're discussing chemistry and really thinking about it very deeply. The Hollywood connection has glamorized science, and I absolutely think this has been very beneficial.

Are there any favorite moments during your involvement with "Breaking Bad" that you could share with us?
There was one scene that people who watch "Breaking Bad" might remember, and that is a scene in which Walt is in the super lab with Gus and Jesse. Walt is talking to Gus about the chemistry behind the pseudoephedrine process and saying, "You cannot do this reaction without me." Walt speaks very strongly about his knowledge of chemistry and the power of science. I really liked that because I thought that drove home the point that scientists generally need to make now—that the general public needs to realize how important science is to everybody because chemistry, in particular, impacts their everyday lives. That made me feel really good...and I helped them write that dialogue and get it correct.

What is your area of research and how was your time at UT?
I'm a physical organic chemist. I got my Ph.D. with Michael Dewar at UT Austin, and he was a fabulous person and very inspirational. He was very supportive of women. I felt very privileged to have been able to work with him. He had a huge influence on the rest of my professional life. He truly was a genius.

Donna Nelson visited the "Breaking Bad" set in Albuquerque and met with cast members Bryan Cranston (left) and Aaron Paul.

Photo: Sarah Wilson

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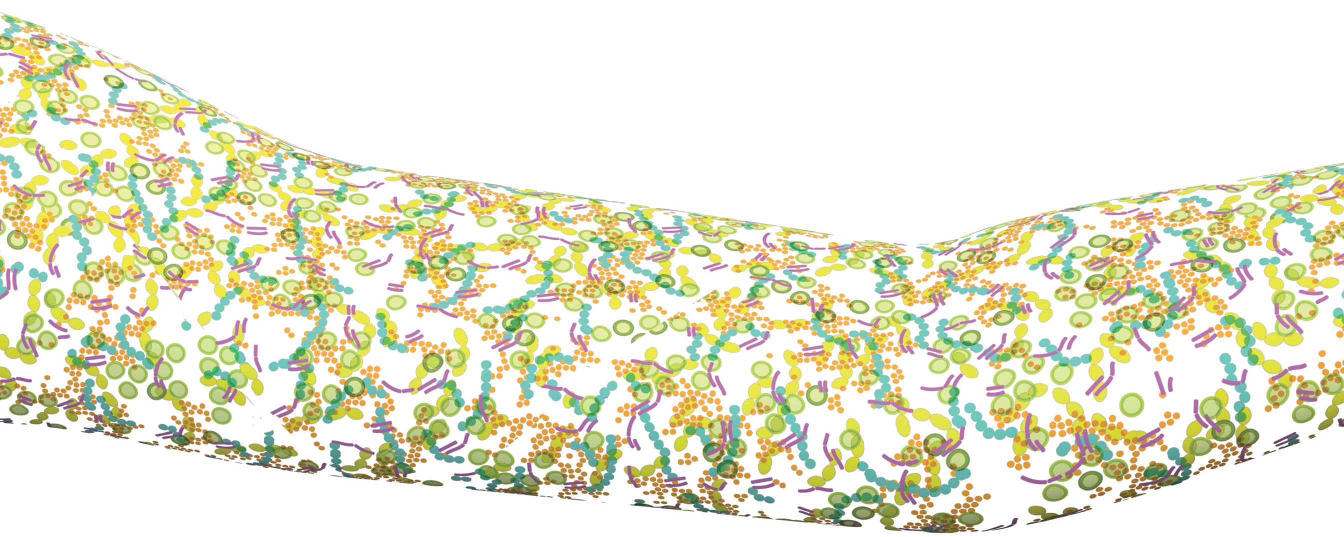
CORROSIVES

YOU ARE YOUR MICROBIOME

by Joe Hanson



Have you ever felt not completely like yourself? You're not alone. In fact, you're never really alone. No matter how hard you may try, you're always in the company of 100 trillion microbial friends.

Say hello to your microbiome, the thousands of species of bacteria and fungi living in and on you. Biologists now understand that our own cells are just one part of an enormous body ecosystem, and they are just starting to understand how the tiny pieces fit together. The microbiome is turning studies of human biology inside out, changing how doctors treat some diseases, and perhaps even redefining a bit of what it means to be "you."

In an era of antibiotic-resistant infections, bacteria often get a bad rap, but we wouldn't be much good without them. Our bodies rely on them in many ways, from helping digest our food and manufacturing essential vitamins in our gut, to training our immune system to fight off foreign invaders. Moreover, our health seems intricately tied to theirs. Disrupted microbiomes have been implicated in conditions ranging from obesity to heart disease.

The idea that our bodies don't completely belong to us is a relatively new one. It wasn't until 2013 that scientists undertook the first careful tally of how many human cells make up the average body. That number, about 37 trillion, is at least a hundred times more than the number of stars in our galaxy. Yet, it pales in comparison to the hundreds of trillions of bacteria and fungi we carry around with us.

In some ways, our appreciation of the human microbiome is evidence of a greater shift in microbiology. For decades, microbes were studied in isolation, one species at a time, viewed as nothing more than bags of genes and enzymes for biologists to pick apart. Now, microbiologists have radically shifted their focus from single species to communities. It's becoming clear that to understand how microbes communicate with us, we need to understand how they communicate with each other.

"Biologists now understand that our own cells are just one part of an enormous body ecosystem."

Communication Breakdown

From his lab on the Forty Acres, microbiologist Marvin Whiteley spends his days listening in on the social lives of bacteria. Much of his lab's research focuses on decoding the molecular mechanisms of "quorum sensing," a method of chemical communication common among bacteria.

Bacteria are constantly sniffing out chemical signals in their environment to determine who's around, and whether they're friend or foe. These signals can influence behaviors ranging from whether the bacteria should divide or feed to if they release toxins or engage defense mechanisms. Complex populations like the human microbiome are crowded quorum sensing chatrooms, full of chemical conversations among the species that call us home.

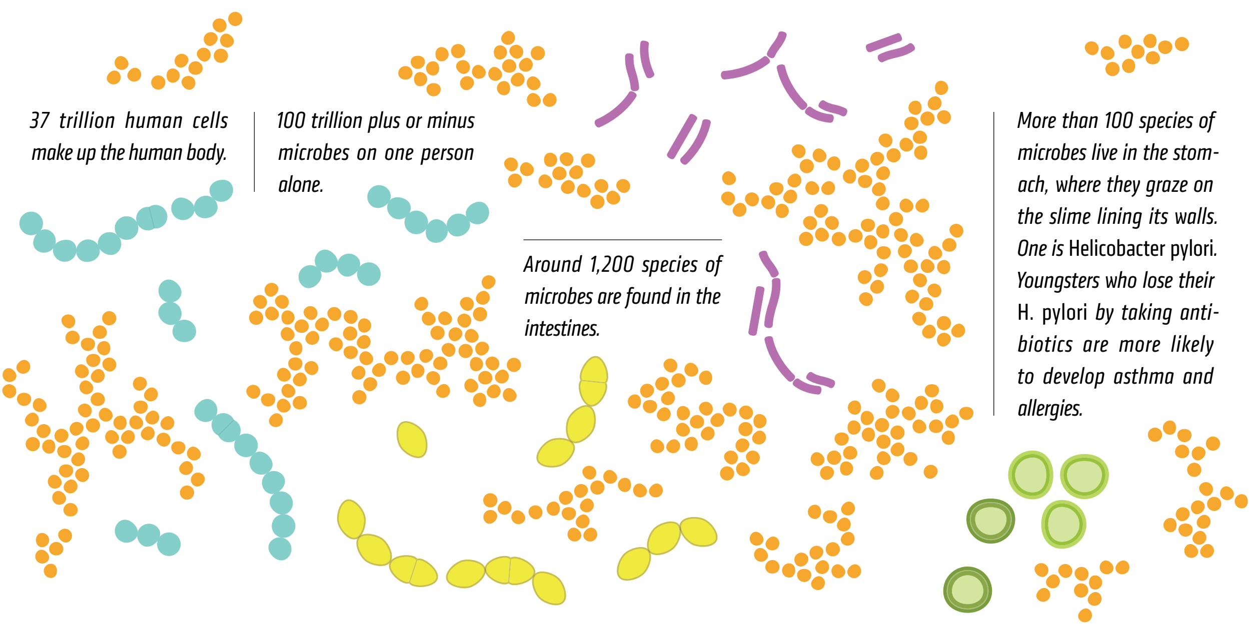
The study of human microbes began in 1683, when a Dutchman named Antonie van Leeuwenhoek placed his own tooth scrapings under a crude microscope. There he saw a host of "...little living animalcules, very prettily a-moving." More than three centuries later, Peter Jorth, a graduate student in Whiteley's lab, is looking at the mouth's microbiome through a modern lens to determine how bacteria cause periodontal disease.

We're used to diseases that act like a cold or the flu. A nasty bug shows up, and we get sick. Getting better simply means getting rid of the unwelcome guest, via medicine or our immune system. But Jorth has found that periodontal disease doesn't work this way. Essentially the same bacteria are present in a healthy mouth and a diseased mouth. It's only their behavior that has changed. Those changes are due to some disruption in their environment, but precisely what triggers it, Jorth and Whiteley don't yet know. What is clear is that our old way of looking at bacterial disease needs an update.

"What we need to know is not who's there, but what are they doing?" Whiteley says. "That's where all of this has to go."

Gut Feeling

Most microbiome research today takes looks past the mouth, into our digestive system. The gut microbiome, swimming around at the center of the body, is quickly becoming the center of human health research. Our guts harbor species like *Heliobacter pylori*,



37 trillion human cells make up the human body.

100 trillion plus or minus microbes on one person alone.

Around 1,200 species of microbes are found in the intestines.

More than 100 species of microbes live in the stomach, where they graze on the slime lining its walls. One is Helicobacter pylori. *Youngsters who lose their* H. pylori *by taking antibiotics are more likely to develop asthma and allergies.*

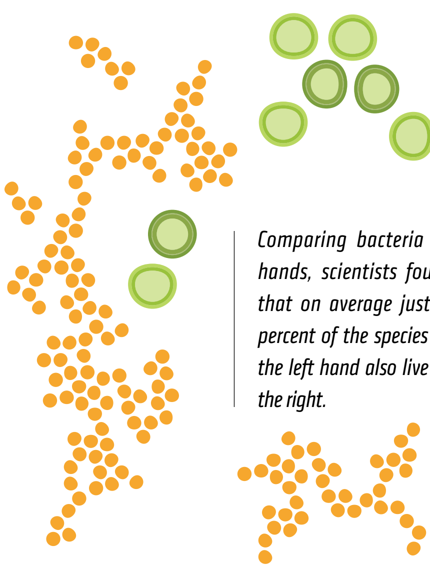
"Along with every dirty thumb and dog lick came more microbes, until you became the ecosystem you are today."

whose imbalance can lead to esophogeal cancer, and *Escherichia coli*, perhaps the best-understood organism on Earth, and which gets its very name from the colon it calls home. They haven't always called you home, though.

You were born essentially sterile, but that changed quickly. On your way out of the birth canal, your intestines were seeded with their first bacteria, some of the same species that you would soon need to digest your mother's milk. It is known that children born by C-section are seeded with different bacteria, but whether this has long-term effects isn't understood.

Your microbiome continued to develop as you nursed, with gut bacteria installing a protective coating on your intestines while your immune system developed. Along with every dirty thumb and dog lick came more microbes, until you became the ecosystem you are today.

And just as you aren't the same person you were when you were young, your microbiome hasn't remained static. Changes in the gut microbiome can have serious implications for your health.



Comparing bacteria on hands, scientists found that on average just 17 percent of the species on the left hand also live on the right.

This year, scientists from Washington University in St. Louis found that mice put on weight when they were "seeded" with the gut microbiome of obese humans, while mice that received "lean" microbiomes stayed thin. And a Swedish team found that particular microbiome populations were linked to type II diabetes, although they weren't able to establish a specific cause.

Of course it's not all bad news. In 2010, scientists found that the Japanese had adopted the ability to digest special sugars in seaweed from bacteria that live on nori, the green stuff used to wrap sushi. And in recent years, as more bacteria gain resistance to commonly used antibiotics, many infections have become harder, if not impossible to treat. The Food and Drug Administration recently approved a revolutionary treatment for antibiotic-resistant *Clostridium difficile* infections, which can cause life-threatening diarrhea, in which the microbiome of a healthy individual is transplanted directly into the infected patient's gut.

While this doesn't mean that the cure for diabetes or obesity is as simple as a pill filled with a few million bacteria, it redefines what it means to treat the "whole patient." Just as changes in our microbiome can spell trouble, doctors are learning that our resident bacteria can be manipulated for our benefit. "The adaptability of the human is really based on the bugs," Whiteley explains.

The lessons we're learning from the human microbiome sound a lot like a Beatles lyric: We get by with help from our little friends.

Joe Hanson (Ph.D. '13) blogs smartly at "It's Okay to be Smart": **www.itsokaytobesmart.com**. *Check out his PBS video series at:* **youtube.com/itsokaytobesmart**.

EDUCATION GOES DIGITAL

by Steve Franklin

By now, you are no doubt aware of the digital revolution sweeping through the world of education. "Flipped" classes, where a heavy emphasis is placed on giving students course content online and class time is used for activity, are becoming the norm.

MOOCs (massive open online courses) are enrolling millions of students across the globe. Then, there are the iPad apps, the Khan Academy, thousands of YouTube videos, and a multitude of other ways that course content is delivered to people via pixels.

edX, a platform for MOOCs with which UT Austin is a partner, now offers more than 90 college courses to the world. Their goal is to educate one billion students worldwide in the next 10 years. And starting in 2014, three of those courses will be run by College of Natural Sciences faculty.

But the fact is, the College of Natural Sciences has been moving into the digital realm for quite some time. Our professors have been some of the earliest adopters—and success stories—of the digital learning revolution at The University of Texas at Austin. The college even developed a web platform called Quest to support faculty in flipping their courses.

So as learning moves online, what happens to the old brick-and-mortar experience for students?

Bye Bye Lecture. Hello Interaction. The lecture course has been the standard in higher ed for time immemorial. An instructor stands at the front of the room dispensing scientific knowledge and the students frantically write down everything. While delivery of this information has changed some over the years, moving from chalkboard to overhead projector to PowerPoint, the student has largely remained a transcriber.

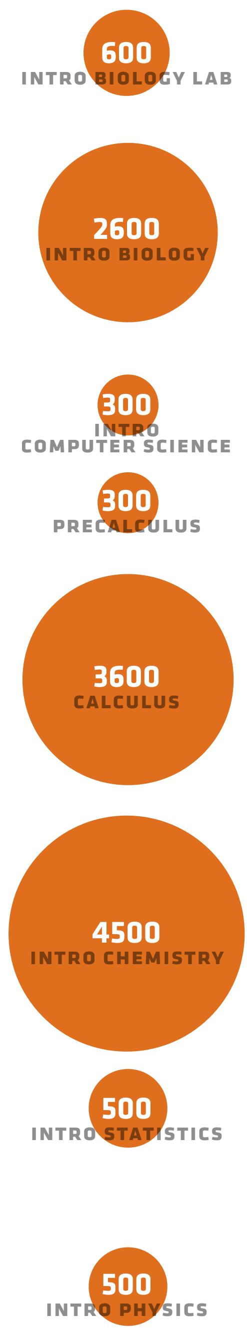
The problem is that nowadays, armed with nothing but a smartphone, students can access much of this information on their own. But while that information is easy to retrieve, students still need to be taught which information is correct and how to use it.

“There are lots of ways that students access information now besides just professors. That’s not our unique asset anymore,” says Sacha Kopp, associate dean of undergraduate education and a physics professor who taught four classes this past fall. “Professors now do a couple of things that I think are far more critical and value-added on a campus. We teach students how to solve problems and use equations or concepts in a science discipline, and we mentor students who are going through a very instrumental period of their professional and personal lives.”

Flipping Out
In light of these changes, over the years the college’s faculty members have been transforming the way they pass on their knowledge and skills. In the flipped classes, students go online and view class content beforehand. They watch videos of complex ideas or interact with online learning modules that give them immediate feedback. In class, they then work in teams and interact in small groups while completing guided learning exercises.

Many college courses, including introductory classes in mathematics, biology, chemistry, physics, computer science, and astronomy, have been transformed in this

Flipped Classes:
IMPACT
(No. students per year)



Flipped Classes:
IMPROVED GRADES
(Data from various classes)

BIOLOGY
Students were
2.6x
as likely to pass flipped courses compared with traditional courses

STATISTICS
57%
fewer non-passing grades in calculus

CALCULUS
59%
fewer non-passing grades in chemistry

CHEMISTRY
68%
fewer students failed or dropped the class

CHEMISTRY
The average course GPA rose more than half a letter grade, **from 2.4 to 3.0**, compared with previous classes by the same instructors

QUEST

An online learning platform developed by the college..

15,000 students per semester use Quest.

way, a few as part of the university's Course Transformation Program, a venture funded by the provost beginning in 2010.

"The class has been completely transformed from a passive lecture class to a very active learning environment where the students are talking to each other, using the language, explaining things to each other in real time," says Cynthia LaBrake, who, along with David Vanden Bout, has been responsible for transforming introductory chemistry.

"It gives them a chance to internalize those ideas in their own words," adds Vanden Bout. "One of the beauties of using technology is that it allows you to do some things better, in particular, by giving students the opportunity to engage in independent learning outside of the classroom."

The multi-faceted system offers a more engaging learning experience for students, who are better prepared to participate in the classroom. The ultimate goal is helping the students.

"We just did it because we thought it would make our class better," said LaBrake.

The results have been remarkable. In biology, first semester students were over twice as likely to pass the transformed courses as regular courses. In chemistry, the average course GPA rose more than half a letter grade compared with previous classes taught by the same instructors.

Online Prep

The college is also using online means to start future students off on the right foot. All incoming freshmen are asked to take placement tests for introductory courses and are given online material to help them brush up on these subjects. Students are given clear feedback on their performance. If they do poorly, rather than have them take a remedial course and set them back a semester, students are asked to review online study materials over the summer, preparing them for the first day of class.

"What we've observed is incredibly positive," said Kopp. "We used to have rates of non-passing grades in calculus and chemistry that were twice as high as they are today, the number of people needing remedial classes dropped by 78 percent."

Steve Franklin (B.S. '11) is a writer and marketing coordinator for the College of Natural Sciences.

Wading Into the World of MOOCs

In 2014, college faculty will be debuting three new MOOCs on the edX platform: "Foundations of Data Analysis" with Catherine Stacy and Michael Mahometa, "Effective Thinking Through Mathematics" with Michael Starbird, and "Linear Algebra: Theory and Computation" with Robert van de Geijn and Margaret Myers. They will be free and open to anyone in the world.

However, before these types of completely digital courses become the norm, one fundamental aspect that MOOCs lack, in-the-flesh interactions with the instructor, has to be studied. Data will need to be gathered to see how the success rate of students is affected and how well they learn.

Starbird, a mathematics professor, views his MOOC as an opportunity to evolve as a teacher.

"I am thinking of it as purely experimental, and many of the experimental pieces won't work," he says. "To me the value will be to learn from the mistakes and thereby participate in the evolution of better presentations. It's a little chaotic. I love it."

Enrollment as of December 18, 2013

Linear Algebra–Foundations to Frontiers

17,956 STUDENTS

Effective Thinking Through Mathematics

29,264 STUDENTS

EVERYONE CAN BE A PHILANTHROPIST

Herman and Joan Suit visit the telescope atop Robert Lee Moore Hall.

Pioneering oncologist Herman Suit spent the summer of 1950 studying nuclear physics at UT. It changed his life, and he went on to break new ground using proton-beam therapy to attack tumors. Until 2000, he served as chief of radiation oncology at Massachusetts General Hospital and as a professor at Harvard Medical School. Like her husband, Joan Suit made her career in science working as a microbial geneticist at MIT.

The Suits have created charitable gift annuities which, after their lifetimes, will support two of their passions at the university—libraries and astronomy. In the years since setting up their annuities, they were so eager to see their philanthropy in action that they began making outright gifts to seed professorships. In the College of Natural Sciences, their gift is supporting Astronomy Professor Karl Gebhardt in his quest to discover dark energy, one of the biggest mysteries in science today.

You can be a philanthropist, too.

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"I'm a Texan, and our state university is important to me."

Herman Suit
Doctor, Scholar and Philanthropist

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