# flux

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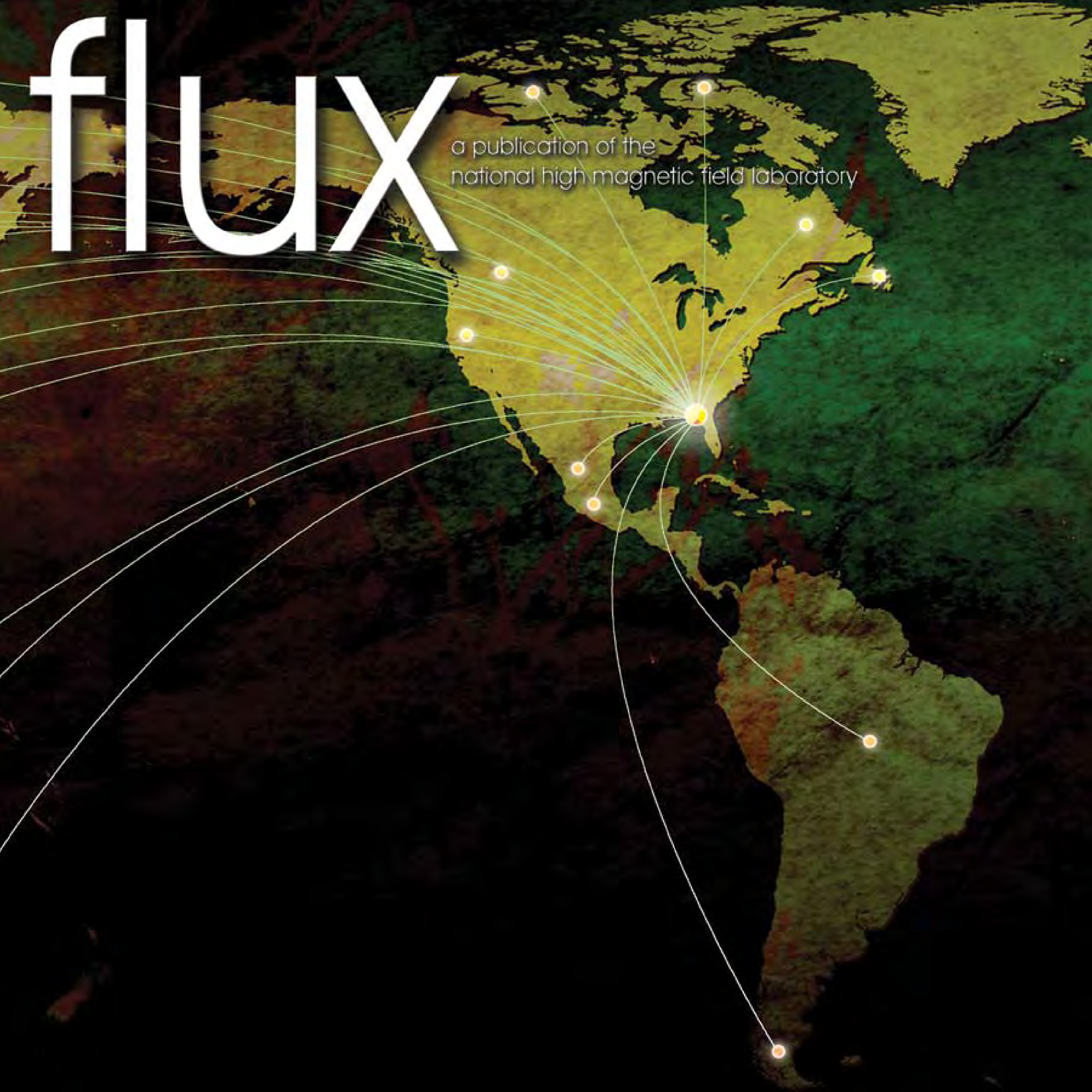

# In This Issue

Volume 2: Issue 1

## FEATURES



# No 'users,' no Mag Lab

Editors' Note

If you spend much time at the Magnet Lab, you'll hear a lot of talk about "users." The users are our bread and butter, because without them, there would be no need for a National High Magnetic Field Laboratory.

Who exactly are these "users?" They are visiting researchers who conduct their research in the lab's high magnetic fields. They are physicists, biochemists, chemists, engineers and materials scientists, to name a few. They come from universities, other national labs, research institutes and industry, and they bring with them graduate students who likely will one day be users – or employees – themselves. They come from Asia and Europe and elsewhere overseas even though there are international magnet labs closer to their homes. Seven hundred scientists and scientists-in-training travel to the Mag Lab's Florida facilities each year; when you include the Pulsed Field Facility in Los Alamos, New Mexico, that number climbs to nearly 1,000.

Users come here because the lab's high-performance magnet systems – most often engineered and built in-house – are cherished for their high field strength and because it's far too expensive for individual scientists to buy these one-of-a-kind magnets for their own laboratories. The lab's flagship hybrid and 900 megahertz magnets, for example, carry hefty price tags of $14.4 million and $15 million, respectively.

The National Science Foundation pays for the magnets and for the operation of the magnets. This means the users conduct their research for free so long as they report their results. And magnet time doesn't come cheap. When it's running at full field, the hybrid magnet burns through $4,000 of electricity an hour. It all adds up: In 2007, the electric bill at the Tallahassee headquarters totaled $6.8 million – 70 percent of which is attributable to magnet use.

Then there are the cryogens, also known as very cold liquids. Liquid helium and liquid nitrogen are used to keep our superconducting magnets at the extremely low temperature they need to operate. Cryogens are also used in magnet testing and development and to keep samples cold during experiments. In 2007, the lab spent $1.5 million on helium and nitrogen.

Our users don't just get access to our magnets, they also get access to the Mag Lab brain trust – Ph.D. scientists, experienced engineers and technicians. Experts in their respective fields, they help set up and conduct experiments and interpret the results.

Clearly, our users use a lot of resources – the experienced staff, costly amounts of cryogens and electricity and, of course, the magnets themselves. It's no wonder scientists are willing to wait years and travel thousands of miles for the chance to use one of the best magnets in the world.

Longtime user Janice Musfeldt of the University of Tennessee cools down her sample.


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**NATIONAL HIGH MAGNETIC FIELD LABORATORY**
1800 East Paul Dirac Drive
Tallahassee , FL
32310-3706

The National High Magnetic Field Laboratory, or Magnet Lab, is a national user facility that provides state of the art research resources for magnet related research in all areas of science and engineering. The Magnet Lab is supported by the National Science Foundation and the State of Florida, and is operated by Florida State University, the University of Florida and Los Alamos National Laboratory.

**MAG LAB DIRECTOR**
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**ASSOCIATE DIRECTOR FOR MANAGEMENT AND ADMINISTRATION**
Brian Fairhurst

**DIRECTOR OF PUBLIC AFFAIRS**
Susan Ray

**FLUX EDITOR**
Amy Mast

**WEBMASTER & WRITER**
Kristen Coyne

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# FIELD WORK Research in big magnets is hot . . . and getting hotter

**By Kristen Coyne**

Way back in 600 B.C. the Greeks first noticed that lodestone attracted iron; a few centuries later, the Chinese began exploiting that knowledge to make the earliest compasses. Since then, the science of electricity and magnetism has come a long way, and men have devised magnets exponentially more powerful than the natural ones that first fascinated ancient minds.

Interest in big magnets endures in Asia, Europe and elsewhere, where scientists and engineers are planning and building new research institutions they hope will rival the biggest magnet lab in the world, the National High Magnetic Field Laboratory.

There's good reason researchers are pushing hard for scarce R&D euros, dollars, yuan and yen to build bigger and better magnets: High magnetic fields can probe the structure and behavior of matter like no other tool. Used alone or in tandem with instruments such as mass spectrometers, lasers and MRI machines, these magnets are both powerful and versatile, with applications in physics, biology, chemistry, geology, engineering and materials science. Whatever the discipline, high-field magnets make possible the kind of heavy-hitting, basic research that deepens our knowledge of the world while drawing us closer to practical applications that will improve the way we live. Higher fields are in high demand among researchers because bigger magnets bring better results.

Greg Boebinger

"It's true," said Greg Boebinger, director of the National High Magnetic Field Laboratory, which is headquartered at Florida State University in Tallahassee. "I can think of a half dozen countries around the world that are now investing so much money in magnet research that they will one day rival, or even surpass, some of our best magnets."

Established by the National Science Foundation in 1990, the "Mag Lab," as it's more commonly known, is home to some of the biggest, strongest, most sought-after magnets on the planet. The shiniest of its crown jewels is the hybrid magnet, a 35-ton behemoth that produces the highest sustained magnetic field in the world. Scientists measure magnetic strength in units called tesla. A fridge magnet is a tiny fraction of a tesla. A 1-tesla magnet can pick up a car, while a 3-tesla runs the average MRI machine. The Mag Lab's hybrid, in comparison, produces a phenomenal field of 45 tesla (see sidebar on magnets, p. 7).

Clearly, today's research magnets are no lumps of lodestone. In fact, they aren't permanent magnets (like those on the fridge) at all, but rather electromagnets, superconducting magnets, or combinations such as the hybrid. From the outside, they look like Thermos bottles on steroids. Inside, they are highly sophisticated instruments requiring great skill and resources to operate. At the center of each sits some of the hottest real estate in science: the magnet's bore. This empty space, measuring at most a few inches in diameter, is where the action happens. Scientists put their experiments in the bore then watch the data roll in.

Contrary to what many might think, scientists don't use research magnets to study magnetism. The magnets aren't the ends, but the means – the means to discovery. Just as a microscope allows us to view details invisible to the naked eye, so do magnetic fields reveal the nature of things – and of the very laws of science that account for them.

How can you "see" things with magnetic fields?  X-ray machines detect broken bones by using a type of energetic light that shines right through your body.

### UNITED STATES

*The National High Magnetic Field Laboratory is the only user facility of its kind in the U.S. The Mag Lab continues to lead the world in magnet technology, but labs around the world are making inroads.*

### NETHERLANDS

*The Radboud University in Nijmegen is investing heavily in the development of a free-electron laser radiation source and a 45 T hybrid magnet system to enhance the capabilities of its High Field Magnet Laboratory.*

### FRANCE

*The National Pulsed Magnetic Field Laboratory in Toulouse has developed a 30 T magnet for use at the European Synchrotron Research Facility (ESRF) in Grenoble. Such a capability is not yet available in the U.S.*

### GERMANY

*The Dresden High Magnetic Field Laboratory combines a free-electron laser with its high magnetic fields, a combination not yet available in the U.S. Dresden is working toward development of a 100 T short-pulse magnet.*

### CHINA

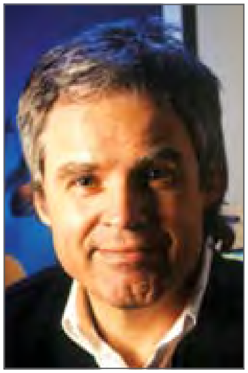
*The Chinese government is spending $48 million to develop its new Hefei High Magnetic Field Lab, which is scheduled for completion in 2012.*

### JAPAN

*Japan may be a small country, but its interest in high magnetic field research is huge. Japan is home to six magnet labs!*

Magnets also exploit electrons – the moving electrons that make up their fields – to examine objects within that field. It all comes down to atoms and the fact that so much of the universe is governed by opposites that attract and like things that repel. If you put something inside a magnet, the positive and negative particles in its atoms interact with each other and with the magnetic field in a way that reveals something about its properties in particular, or about the properties of matter in general.

There are lots of questions you can answer with a magnet. For example, what kind of materials will work best in tomorrow's faster, smaller computers? What changes does a potential Alzheimer's drug stimulate in the brain? What molecules make up a sample of crude oil – and is it worth drilling for? What is the best way to build a superconducting cable – and save untold billions in electricity costs?


Horst Störmer

"High magnetic fields have always been an essential tool in the tool box of physicists," said Columbia University physicist Horst Störmer, who shared the 1998 Nobel Prize in Physics for the discovery, made with the help of high-field magnets, of a new form of quantum fluids. "Nothing is comparable to standing next to these giant, roaring magnets, generating stable magnetic fields higher than anywhere else on the globe, and have data emerging that seem implausible at first, but actually represent a new discovery in physics."

This is tantalizing stuff for scientists. That's why China is spending some $50 million on its new High Magnetic Field Lab, part of $750 million that country is investing in science infrastructure. That is also why the Europeans are planning to consolidate their four magnet labs (two in France, one each in Germany and the Netherlands) under a single umbrella institution, the European Magnetic Field Laboratory. Taking a nod from the Mag Lab, which has sites at the Los Alamos National Laboratory in New Mexico and the University of Florida in Gainesville, the Europeans hope this multiple campus model will eliminate duplication of effort and allow each facility to produce its best research.

If there is a competitive aspect to these magnet development efforts, there also is a lot of cooperation. International collaboration can only further science, and few institutions offer better living proof of this than the Mag Lab. Its staff is made up of experts from around the world, and of the thousand scientists who travel to the lab every year to conduct experiments, nearly a quarter come from overseas.

A scientist's research can only be as good as her instruments. Today's magnets have the highest fields that materials and technology will allow. But stronger materials and more advanced technologies now under development will lead to even higher fields. These mightier magnets will extend scientific techniques while lowering operating costs – which now run well into the millions of dollars annually at the Mag Lab alone. That incentive has pushed the Mag Lab to become one of the world's leading designers and builders of magnets. With $20 million in contracts and grants, the lab's engineers are currently building a pair of series connected hybrid magnets, a novel design that will reach higher fields with less electricity. One of these magnets, funded by the NSF, will be located in the Mag Lab's Tallahassee headquarters; the second is headed to Germany's Helmholtz Centre Berlin, where it will be used for neutron scattering.

The scientific community's appetite for knowledge extends to other magnets as well. Under the auspices of the National Academies, which advise the U.S. government and public on science and technology issues, the Committee on Opportunities in High Magnetic Field Science issued a report in 2005 underscoring the need for more powerful magnets. Noting that "the prospects are bright for future gains from high-field research," the report called specifically for the development of a 30 tesla nuclear magnetic resonance (NMR) magnet, a 60 tesla hybrid magnet and a 100 tesla long pulse magnet – all projects that will require the development of new materials and interinstitutional collaborations.


Myriam Sarachik

Myriam Sarachik, a distinguished professor of physics at City College of New York, looks forward to the day those tools open more new areas of discovery for physicists, biologists and other scientists. A member of the National Academy of Sciences, Sarachik said she hopes the U.S. can maintain its impressive lead in high-field magnet research: It's one of the scientific niches in which the country still dominates. That leadership not only benefits U.S. science and industry, she noted, but scientific collaborators across the globe.

"Other parts of the globe are slowly coming up to our level—and not so slowly in some instances," said Sarachik. "These unique high-field magnets have been a tremendous advantage to the U.S. position in scientific research and innovation."

## ***MAGNETS AT A GLANCE***

- *RESISTIVE magnets (also called Bitter magnets or electromagnets) require lots of electricity and cooled water. Resistive magnets can reach and sustain high fields over many hours, but they are costly to operate and use is limited by the amount of power available.*

- *SUPERCONDUCTING magnets require little or no electrical power to run once they are brought up to full field because they are made with superconducting materials that conduct electricity without resistance as long as they are kept extremely cold (as low as one degree above absolute zero temperature, depending on the material). While they are cheaper to operate, the strength of field is limited by properties of superconducting materials.*

- *HYBRID magnets combine resistive and superconducting technology, taking advantage of the strengths of each; resistive coils are nested inside the superconducting coils, the latter of which account for most of the magnet's weight and volume. Hybrid magnets produce the highest sustained magnetic fields possible.*

- *PULSED magnets produce much higher fields (up to 89 tesla) than the other magnet technologies, but the high field lasts only seconds or fractions of a second.*

- *SERIES CONNECTED HYBRID magnets, like the conventional hybrid magnets described above, combine resistive and superconducting technology. But the series connected magnets, currently being built, differ in that they are driven in series with the same power supply, rather than independently. This creates the high fields using less power.*

# Little explorers: Small mammals in high magnetic fields

**By Amy Mast**

The combination of live animals and high magnetic fields is a relatively new and unexplored realm in biology. How will animals react to the fields? What will we see and what can we learn?

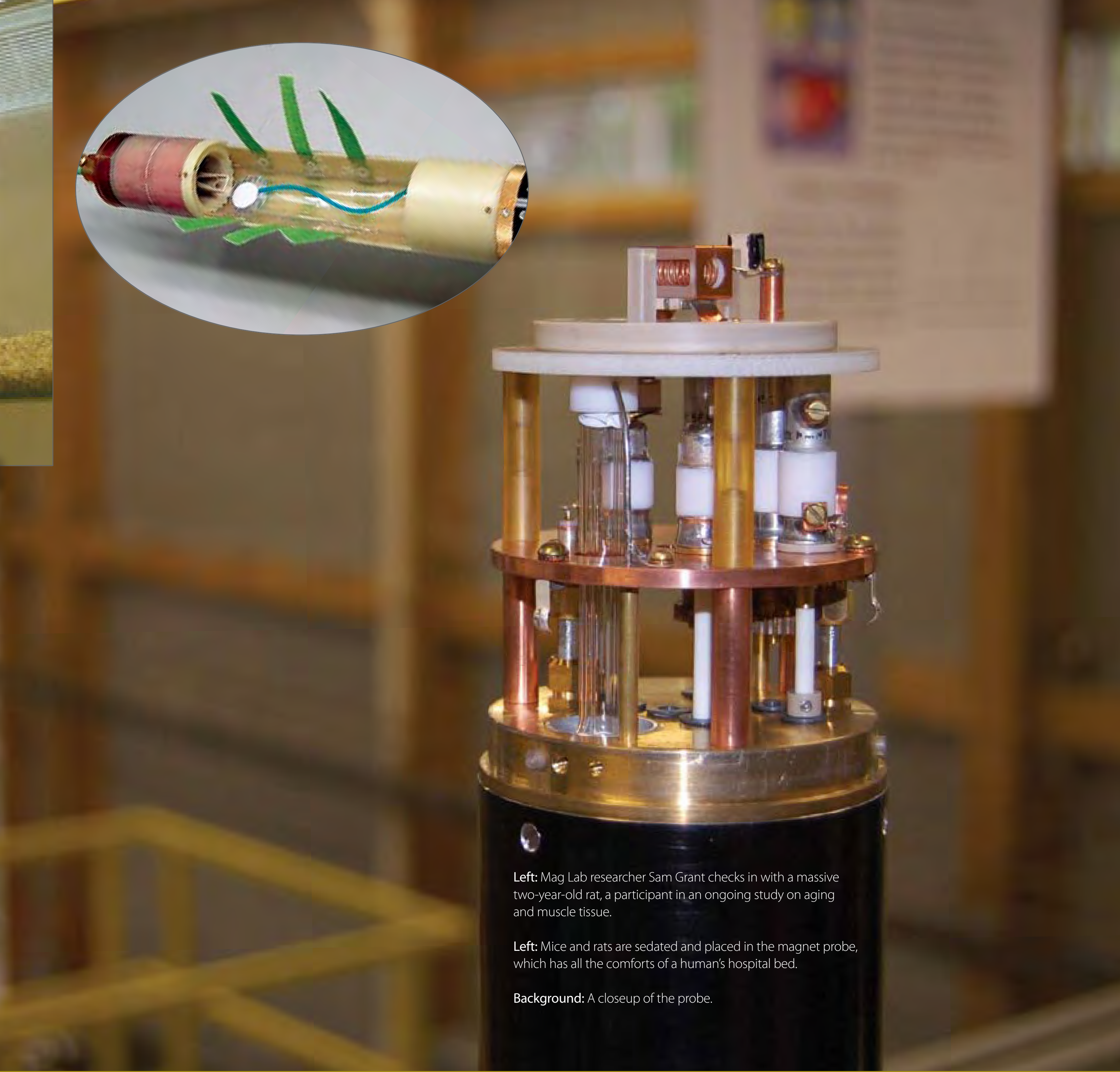
Researchers using the lab's powerful 900 megahertz superconducting magnet are taking steps toward answering these questions with a suite of experiments designed to monitor living mice, rats and birds that are sedated and placed inside the magnet. The magnet acts like the same MRI machine you'd use at the doctor's office, but because the magnetic field is so much higher, it gives researchers a far more specific, detailed look at living tissue.

These pint-sized pioneers experience magnetic fields several times higher than any human being has ever been exposed to. A typical MRI machine uses a 2-3 tesla magnet (tesla is a measure of magnetic field strength); the 900 MHz magnet reaches 21.1 tesla.

"This technology is relevant for a wide variety of research, allowing scientists to track changes in their specimens over time," FSU assistant professor and Mag Lab researcher Sam Grant explained. For scientists, this means longer experimental relationships with the same animal, and fewer animals needed to gather data – a more humane and cost-effective approach to research.

Current live animal research projects at the Magnet Lab encompass everything from the study of diseases such as cancer to the aging process. Researchers use animals to examine decay of muscle tissue caused by aging and to evaluate various treatments and exercise regimens. They evaluate effects of different treatments on cancerous tumors, study the impact of brain injuries, examine the effects of long-term exposure to high magnetic fields, and investigate the progression of neurodegenerative diseases such as Alzheimer's and Lou Gehrig's diseases.

Researchers use customized monitoring equipment, much of which is built here at the lab, that allows the heart rate, respiration, and temperature of an animal to be monitored while it is inside the magnet. It's not unlike the system used to monitor a person undergoing an operation, but it's as delicate as if it were built for a porcelain doll.



**Left:** Mag Lab researcher Sam Grant checks in with a massive two-year-old rat, a participant in an ongoing study on aging and muscle tissue.

**Left:** Mice and rats are sedated and placed in the magnet probe, which has all the comforts of a human's hospital bed.

**Background:** A closeup of the probe.

Animals are sedated before monitoring equipment is placed on them and before they're put inside the magnet. Sedation reduces stress on the animal and allows researchers to monitor respiration, temperature, attach heart monitors and conduct imaging without interruption.

An animal placed in the magnet is removed from its habitat and placed in a separate enclosure, where it breathes in the gas that sedates it. Once sedated, it is placed inside a cylindrical probe that will go into the magnet. The animal lies on a heated pad through which warm water circulates to keep the animal at a comfortable temperature. A small pillow is placed against its body; the pressure against this pillow measures respiration. A tiny bit – like a bit for a horse – is placed in the animal's mouth, allowing a steady supply of sedating gas. The animal is then placed inside the bore at the center of the magnet.

Though the effects of high magnetic fields on living beings are not yet fully known, data so far suggests that exposure to high magnetic fields is not harmful. In-vivo research in high magnetic fields is a new and promising way to gather information about tumors, head injuries, and neurological disorders using an animal model.

Though research is largely conducted on rodents, other animals such as finches have been studied with 900 MHz magnet. The largest participant so far? Big rats. At 350 grams, rats are the biggest animals that can fit comfortably inside the magnet's central experimental space, which is roughly the diameter of a baseball.

In-house scientists and researchers from FSU's medical, human science and engineering schools glean information from animal work with the 900-MHz magnet. As with all the Magnet Lab's scientific programs, the animal program is open to users from other institutions. The Magnet Lab now offers animal storage and procedure space for visiting scientists as part of a larger lab goal to expand its biology research.

The animal storage space looks just like a boarding kennel where you would drop off a pet for the weekend, only much, much cleaner. In a room for procedures, tiny, rodent-scale exercise equipment lies in wait for the next aerobics session. Inside the housing area, mice and rats eat, sleep and play in their enclosures, seemingly unaware of how many secrets their bodies give to researchers while they're asleep.

## About the 900-MHz magnet

Completed in 2005, the 900-MHz magnet, with a 105-mm bore (about four inches), is the largest magnet of its kind in the world. A superconducting magnet designed and built in Tallahassee, it stands 16 feet tall, weighs more than 15 tons, and took 13 years to complete. Its large bore allows scientists to examine larger samples and animal models, providing more information about higher order biological systems that more closely mimic human physiology. Coupled with unprecedented sensitivity and resolution, the large bore size permits for a greater range of scientific experiments. To learn more about the 900-MHz magnet and other research conducted at the Magnet Lab, visit http://www.magnet.fsu.edu/.

### DID YOU KNOW?

- *Research using live animals is called in vivo, Latin for "within the living." Research on individual cells that are not part of a living creature, such as in a biopsy, is called ex vivo.*
- *Lou Gehrig's disease, one of the diseases researched in the 900 MHz magnet, is also known as amyotrophic lateral sclerosis, or ALS. It's one of the more common neuromuscular diseases in the world, and progression of the disease gradually robs the sufferer of movement. First described in 1869, it's still one of the most mysterious and difficult-to-treat diseases in the world.*
- *Although the research animals are sleeping comfortably in a temperature-controlled pod inside the magnet, the magnet itself is temperature controlled with ultra-cold liquid helium.*

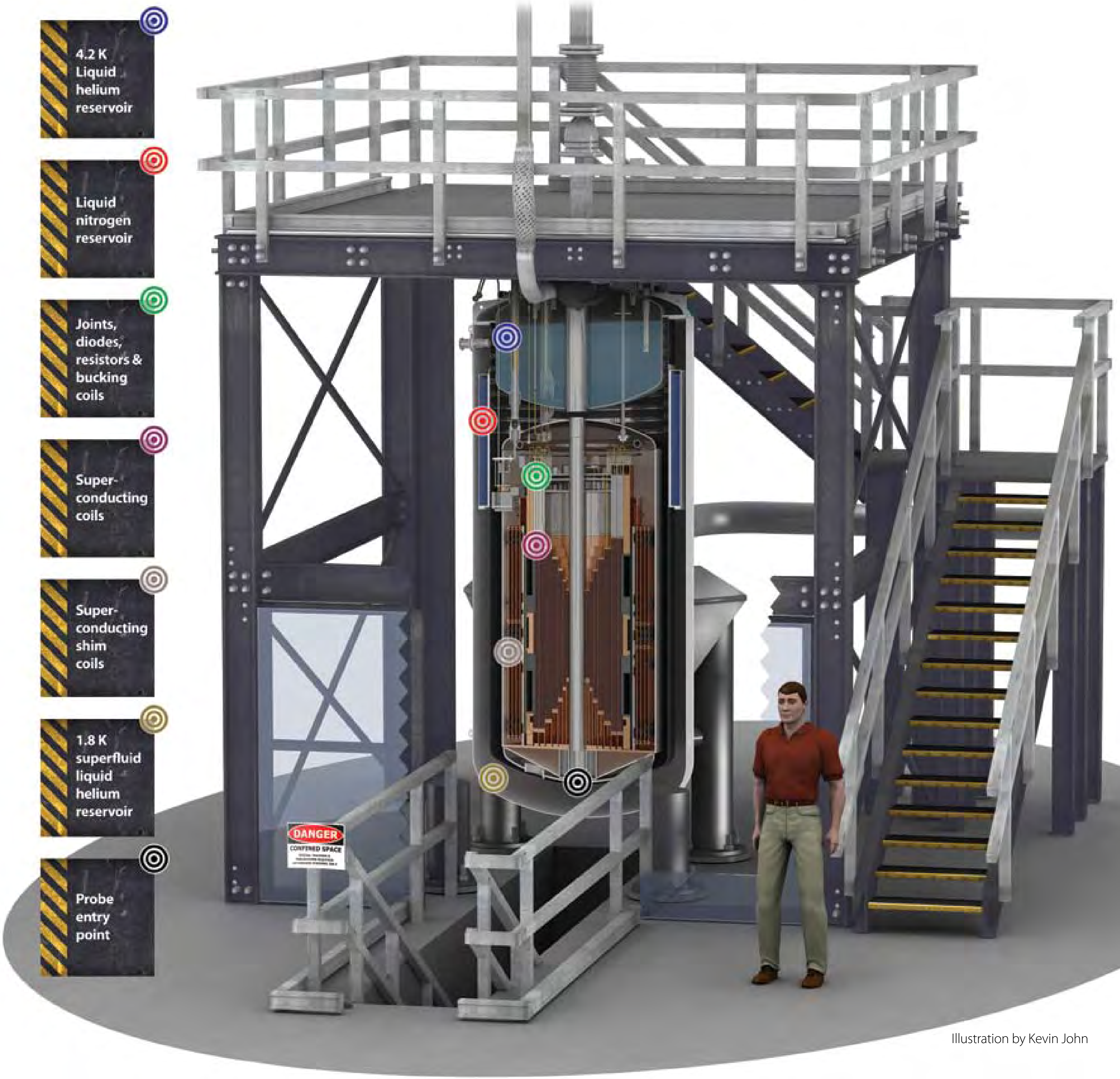
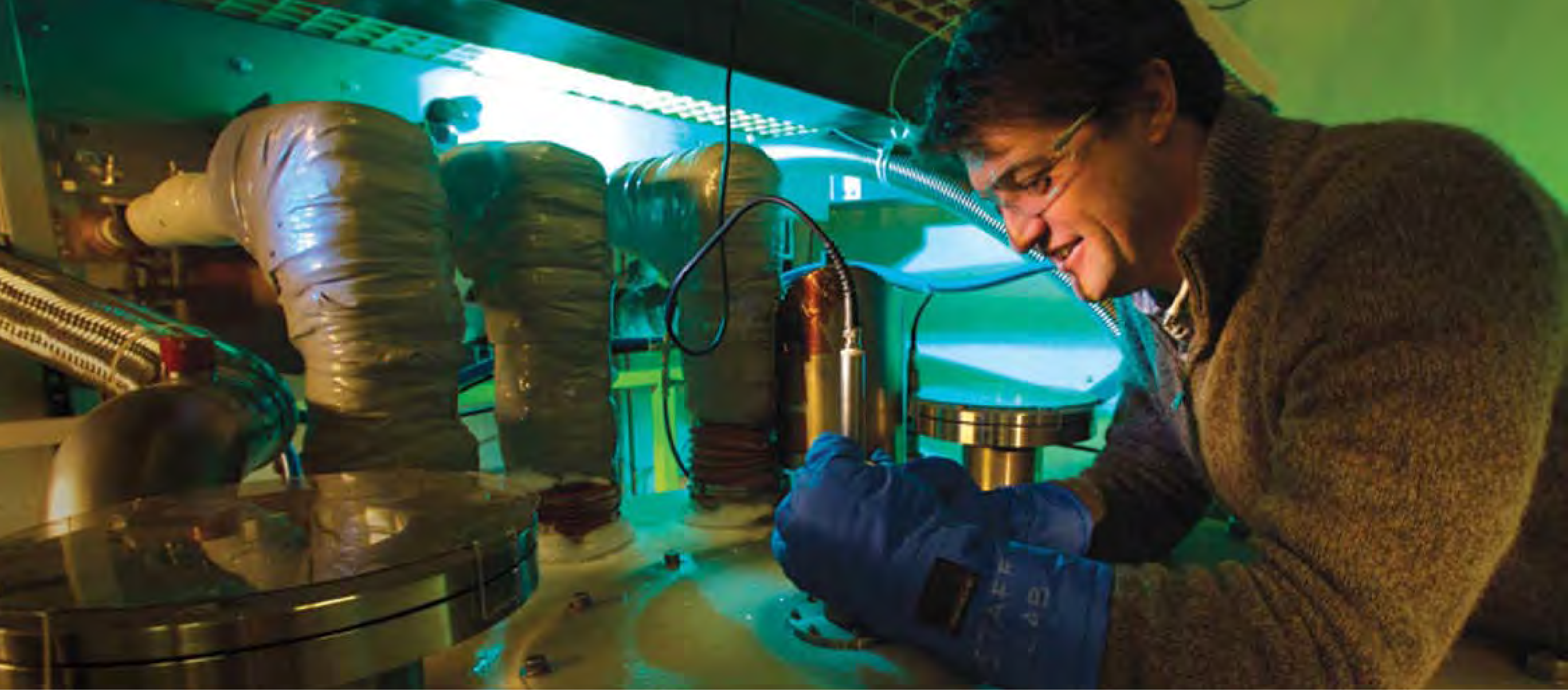



Illustration by Kevin John



Ross McDonald, a physicist at the Mag Lab's Pulsed Field Facility in Los Alamos, lowers a probe through the top of the 100-tesla multi-shot magnet, which currently reaches 90 tesla. Photo courtesy of Los Alamos National Lab.

# SCIENCE TO THE MAX

## Researchers go to extremes to learn about materials

**By Susan Ray**

Forces equivalent to 200 sticks of dynamite… Temperatures colder than the farthest reaches of space… Inconceivable amounts of pressure!

Sounds like a promo for a show on the Discovery Channel that spells extreme as "Xtreme." It's not (yet), but if it were, the setting would be the National High Magnetic Field Laboratory and the plot would involve physicists placing tiny materials under extreme conditions to perform experiments so grueling the materials would howl in protest – if they could.

Fortunately, they can't.

Scientists at the Magnet Lab put tiny crystals in big magnets, cool them to temperatures that make Pluto seem temperate, put them in high-pressure chambers made with gemstones, and bombard them with high magnetic fields. They often do all of these things at the same time.

Scientists go to such great lengths because exposing materials to unnatural conditions tells scientists a lot about them on a molecular level. Under such conditions, materials take on new properties or behaviors: A so-so conductor of electricity, for example, can become a *super*conductor – conducting electricity with no resistance – when cooled to very low temperatures.

### Under pressure

Say you have two people of similar weights. One is wearing work boots and the other is wearing stiletto heels. If the person

Once assembled, the diamond anvil cell is no bigger than a fingertip.

wearing the boots steps on your bare foot, it will hurt, but your foot will remain intact. If the person wearing *stilettos* steps on your foot, however, you'll get a nasty puncture wound. This is because although the force is the same, the boot has a wide base, and the stiletto heel is very narrow.

That is your crash course on the concept of pressure. The formula (don't be afraid, it's just division) is **pressure equals force divided by area**. The more concentrated and stronger the force, the greater the pressure.

Pressure adds new properties to or transforms almost all materials. Think about it: if you put the major squeeze on an object, such as an orange or a balloon, something is going to happen.

Scientists use a lot of different units to measure pressure; we'll use "bar" as our unit. One bar is equal to atmospheric pressure. That's what you feel (or in most cases, don't feel) living here on Earth. You are probably familiar with pounds per square inch (PSI) from filling your car's tires. One bar is the same as 14.5 PSI. (Standard PSI for most car tires is 32-35 PSI.)

When scientists at the Mag Lab want to bring out the big daddy of pressure tools, they use a special pressure device with lots of bling: The diamond anvil cell, or "DAC," pictured above. Once the parts are assembled, the material inside isn't going anywhere (hence the name "cell.") The cell uses diamonds because they are so strong – and they need to be. The DAC is capable of reaching pressures as high as 40 kilobar. That is roughly equivalent to one fully inflated big-car tire running over your foot… with 15,000 cars stacked on top of it. You could say it's equivalent to 15,000 times the pain you'd feel if a car ran over your foot.

That example has a high wow factor, but it's not quite accurate, because the pressure applied by a diamond anvil cell is uniform and coming from all directions. So let's consider pressure from water. When you swim to the bottom of a deep pool, your body feels more pressure because the weight of the water above creates pressure in the deeper water. Well, you'd have to swim down 255 miles to equal the PSI of 40 kilobars.

All of that pressure is focused on the faces of two flawless brilliant-cut diamonds, totaling between one half and 1 carat, which are placed in two separate chambers. The two chambers, with the material to be studied in the middle, are clamped together with a hydraulic press. Now you have the "cell," which is no bigger than the tip of a finger.

Beauty then goes inside the beast: A very powerful, high-field magnet (more on that later).

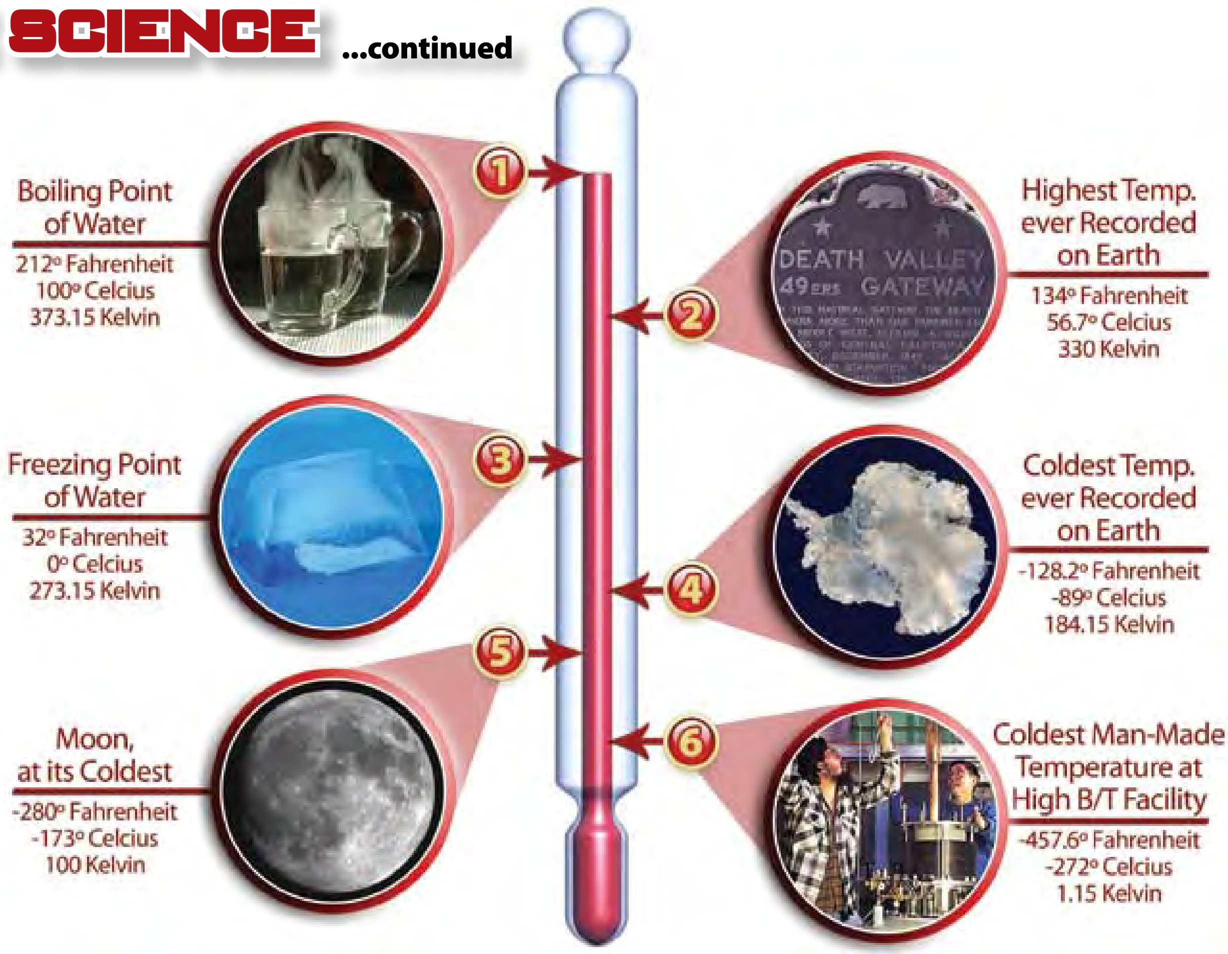
All this effort can lead to important information. Magnet Lab scientists are currently using diamond anvil cells to better understand radioactive elements called actinides. Research in this area can offer a better understanding of the implications of using and storing nuclear fuels, such as enriched uranium.

## How low can you go?

Anyone who has visited the Mag Lab Open House knows that very cold liquids are very cool. Flowers dipped in liquid nitrogen shatter when tapped on a table and bubbles blown over a tub of liquid nitrogen dance above the surface.

The Open House demonstrations are child's play compared to the low temperatures scientists employ at the Mag Lab. And of many cold places at the Mag Lab, the coldest is the High B/T

Facility in our University of Florida location. This facility is located in the *Micro*kelvin building for good reason. First, an explanation of "Kelvin." Physicists talk about temperatures using the Kelvin scale. Zero K is absolute zero – so cold it's hard to find anything to compare it to. You know how cold it is in outer space? Doesn't touch the cold of absolute zero. The coldest day ever recorded on Earth (in nature) is -129 degrees Fahrenheit, which equals 183 K. The High B/T Facility (where B is magnetic field and T is temperature) can produce temperatures as low as -459 F, or 0.0003 K (which is 0.3 thousandths of a degree above absolute zero). Now we're talking!




So what are they making so cold? The material under study, or "sample" as the scientists refer to it, that goes inside the magnet. Why does it need to be so cold? Because at ultralow temperatures, virtually all molecular motion stops. Think about water. It boils because the heat excites the molecules, which start bouncing into each other. There is little (visible) movement in ice, however, because the cold diminishes the molecular motion.

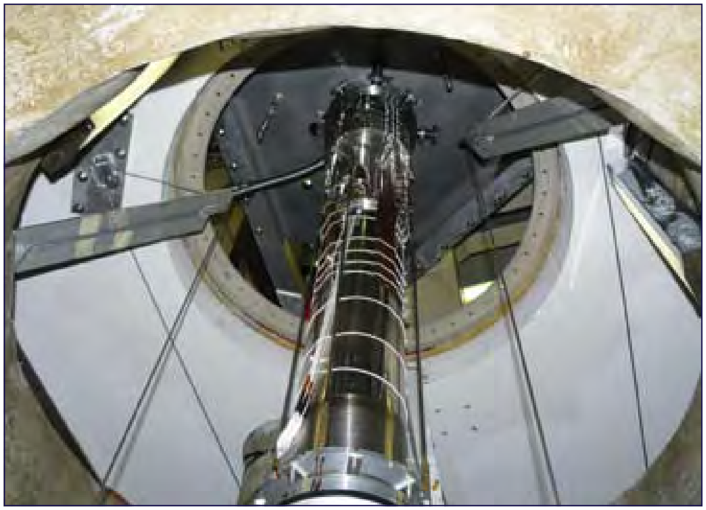
At microkelvin temperatures, radio frequency waves from a cell phone, radio or TV can interfere with the extremely sensitive electronics capturing the data, or cause the sample to rise in temperature, thereby ruining the experiment. Scientists in the low-temp field must also contend with vibrations. The tiniest quiver can heat up the sample. To prevent this, the facility is housed in an "ultra-quiet" environment. Experimental equipment in cryostats is suspended from concrete tripods whose feet are anchored in 5-ton blocks sitting in beds of compacted sand. (A cryostat looks like a big Thermos bottle, and it holds and cools the sample.) The cryostat and measurement systems are housed in a room sealed in steel and copper that sort of looks like a secret vault.

Scientists go to these extremes because certain physics phenomena can only be observed at such low temperatures. For example, some liquids – helium 3 and helium 4 – become superfluids at very low temperatures, which means they flow unimpeded with no viscosity to slow them down. It's the same idea as superconductivity, only with a liquid. Scientists want to better understand what happens when the fluids cross over into the super state.

High B/T experiments take from three to nine months to conduct, which explains why fewer than 10 experiments are conducted there each year. Low-temperature physics is an intense area of research for which several Nobel Prizes have been awarded. In fact, several of the facility's users are Nobel laureates.

## We've got the power

So now you know scientists cool materials to unimaginable temperatures and put ridiculous amounts of pressure on them. We would be out of business if scientists didn't also expose the materials to high magnetic fields. Of course they do, and the Mag Lab's fields are the highest in the world.



Cables on both sides support a cryostat that is suspended and shielded to protect against noise and vibration, which could heat up the sample inside.

Magnets are another way that basic science can shed new light on the unknown. Like microscopes, high field magnets allow us to view and measure details invisible to the naked eye, revealing the hidden nature of matter. Sometimes what they find jibes with the laws of nature – sometimes, it doesn't. That's why there is such a thing as quantum mechanics.

Our magnets are so big and powerful because stronger magnetic fields yield more data, just as a microscope that magnifies 100 times tells you a lot more than one that magnifies only 10 times.

### LEARN MORE

*How do scientists reach such low temperatures? How do the magnets actually work? Learn this and more at the Magnet Academy. Visit www.magnet.fsu.edu/education.*

Scientists measure magnetic-field strength in units called tesla. A run-of-the-mill refrigerator magnet is 0.03 tesla, while a typical MRI machine features a 2 or 3 tesla magnet. Our magnets put them to shame.

The highest magnetic field currently attainable is 90 tesla. This magnet, housed at the lab's Pulsed Field Facility in Los Alamos, New Mexico, will, with some more fine-tuning, soon reach 100 tesla – and when it does, it will have to withstand forces equivalent to 200 sticks of dynamite detonated inside a space the size of a gumball.

Now, scientists can reach higher fields, much higher, than 90 tesla – but the magnets that create the field are destroyed in the process. They are referred to as "destructive" magnets. Talk about extreme!

In nondestructive magnets, forces inside the magnet are trying their best to tear the magnet apart as the fields go higher. This explains why at 90 tesla, the field can only be sustained for 15 *milli*seconds. It also explains why the magnet sits in a huge bath of liquid nitrogen cooled to -324 F. In that extremely brief 15 milliseconds, the temperature of the liquid nitrogen changes from -330 F to 40 F from energy transfer.

Far from boring, science at the Mag Lab is X-citing. Check it out for yourself at *www.magnet.fsu.edu*.

*Thanks to the scientific advisers on this story: Greg Boebinger, David Graf, Eric Palm, Kenny Purcell and Stan Tozer.*

# Mag-Lab pioneered Bitter plate set a new standard

**By Kristen Coyne and Amy Mast**

In the last issue of *Flux*, we talked about the invention of the Bitter plate by MIT physicist Francis Bitter. Didn't catch our last issue? A quick recap:

Bitter plates are quite literally the building blocks of a resistive magnet coil. Metal plates filled with tiny, evenly spaced holes are stacked one on top of the other and the current runs through the plates to create the powerful magnetic field resistive magnets are famous for.

An MIT physicist named Francis Bitter came up with the idea for stamping holes in the plates back in the 1930s, an innovation that made more powerful magnets possible. Back in Bitter's day, the holes, through which cooling water flows, were round, and his invention remained relatively unchanged for about 60 years.

## Adaptation made higher fields possible

In the mid-1990s, Mag Lab engineers figured out that using elongated rather than round holes would greatly increase the coil's ability to withstand stress, meaning even more current could be pumped through the magnet resulting in a higher magnetic field — an incredible 40 percent increase in efficiency.

The Mag Lab's Florida Bitter plate was quickly adopted by magnet makers worldwide; the design paved the way in 1995 for the lab's world-record 30 tesla resistive magnet (tesla is a measure of magnetic field strength — a fridge magnet, by comparison, is a mere 0.03 tesla). This was surpassed in 2005 by our 35 tesla resistive magnet, which remains the most powerful magnet of its kind on earth.

The secret in designing these holes is to find the right balance between the amount of copper used (maximizing the current) and the amount of copper sacrificed to the cooling holes (preventing a melt-down). Made of high-strength copper alloys, Florida Bitter plates can withstand both the pressure resulting from high magnetic fields and the heat resulting from the 19.6 megawatts of electrical power that make it run. The magnetic field is concentrated in the big hole in the middle of the plates; that's where researchers put their experiments.

## Plates are exquisitely engineered

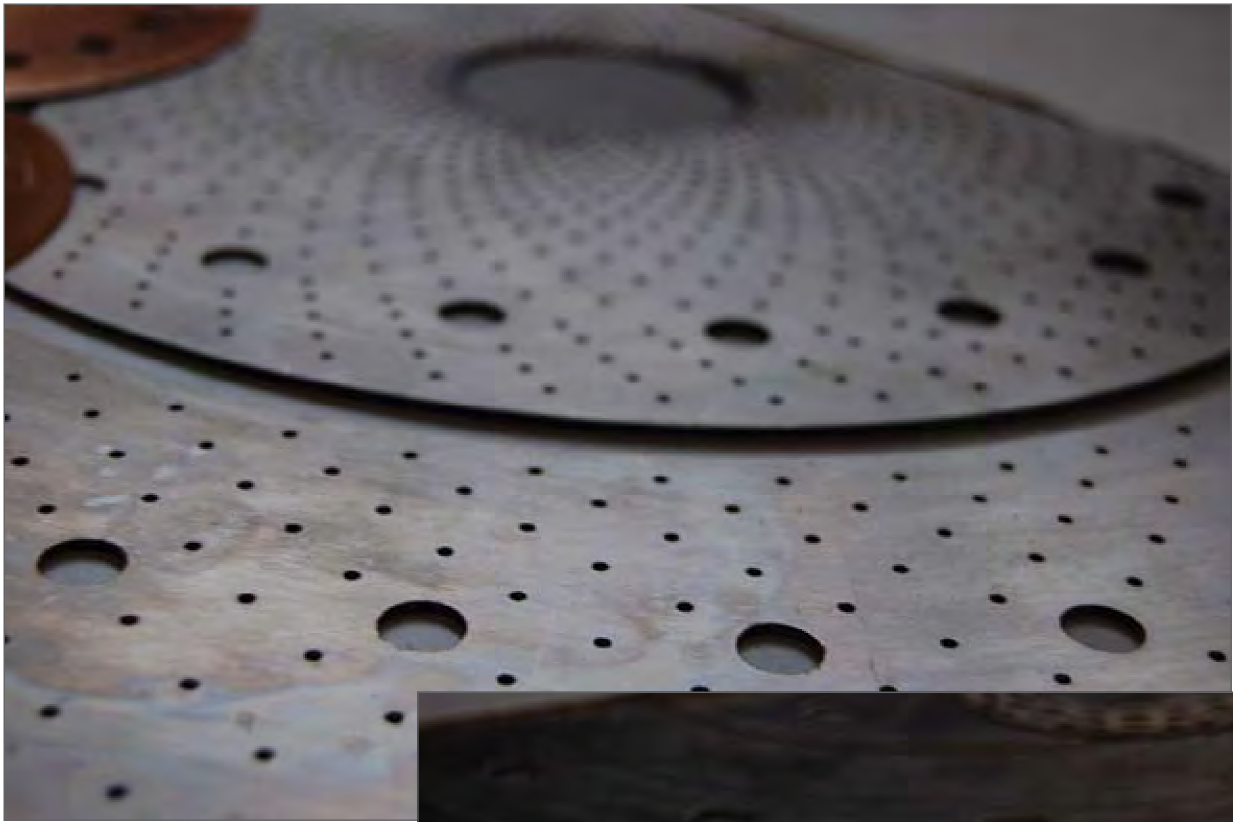
There's quite a bit of science and engineering that goes into determining the precise size, shape, number and pattern of holes on any particular plate, which vary from magnet to magnet.

The larger, round holes accommodate vertical rods that are used to keep the plates in place as they are stacked one on top of the other.

The narrower, elongated holes prevent the plates from melting. They do this by funneling vast amounts of cold water – at a speed of 45 miles per hour – right through the magnet, made quite hot by tremendous amount of current. Were it not for the 45-degree Fahrenheit water rushing through at the rate of up to 4,000 gallons a minute, our magnets would quickly melt into copper puddles. Deionized water is used to cool the magnets. Unlike tap water, it contains no salt or other impurities, and therefore won't conduct electricity.

### DID YOU KNOW?

▷ *A megawatt is a measure of energy in the same family as your 100-watt light bulb. (A watt equals one joule of energy per second.) Adding "mega" to "watt" simply moves the measurement into the millions of units. Megawatts are a measurement used to describe big-ticket energy consumers such as power grids, aircraft carriers, lightning strikes, and yes, research-grade magnet systems.*



*For decades, the Bitter plate differed little from this model, pioneered by Francis Bitter in the 1930s.*

*Innovators at the Magnet Lab pioneered the design of a plate that stood up to higher magnetic fields and more power, the Florida Bitter plate.*

Scientist Spotlight

# When curiosity makes a career

**By Amy Mast**

***Magnet Lab Applied Superconductivity Center Director David Larbalestier is viewed by many of his peers as the leading researcher in the United States, and possibly the world, in the basic research of practical superconducting materials for magnets and power applications. Over a 35-year career, he has profoundly influenced the development of high-field magnets for high-energy physics and other applications, such as magnetic resonance imaging. Among the highlights of his career is his election in 2003 to the prestigious National Academy of Engineering.***

Most of us get frustrated when faced with a question we can't answer. We'll pass it off to someone else, come back to it later, or abandon it altogether.

David Larbalestier, however, has made a career of tackling questions that may not be answered in his lifetime, if ever. Those questions – all related to the phenomenon of superconductivity – have energized a generation of researchers, because knowing the answers could transform how the world delivers and stores power.

Larbalestier directs the Magnet Lab's Applied Superconductivity Center (ASC), where he has assembled a team from senior scientists on down to graduate and even undergraduate students to look at superconductors from every vantage point. Superconductors are materials that conduct electricity with no resistance. Electricity comes from electrons traveling through wire conductors. Those electrons bumping into each other generate an enormous amount of heat. With superconductors, however, there is no jostling, therefore no heat. But there's a catch: superconductors only behave this way when they are cooled to very low temperatures. The ASC, among other things, hopes to develop materials that super-conduct at higher temperatures, with the "holy grail" of achieving superconductivity at room temperature.

The ASC functions as a division within the Magnet Lab. The group, including senior colleagues Eric Hellstrom, Alex Gurevich, Peter Lee and Bill Starch, moved to Tallahassee along with Larbalestier from the University of Wisconsin around two years ago, with virtually all of the Center's 20-strong team intact. It's a group Larbalestier, 65, has built up over a 35-year career as a researcher and professor – a career that could have easily been in politics or the humanities. He came of age, after all, in the 1960s.

## Bouncing between arts and sciences

The son of a Royal Air Force pilot who'd left school at 14, Larbalestier was born in 1943 and grew up in postwar London, a city gravely damaged by World War II.

"During that time," he explained, "life was pretty constricted, and around me was this idea that education was valuable because, frankly, you just got a better life."

The postwar British educational system immersed its students in a rigorous, classical program of studies, and Larbalestier navigated the UK's equivalent of high school with a focus on the humanities (particularly language) rather than the sciences. The complex systems he discovered in his science classes, however, soon had as much appeal for him as the complex systems he'd enjoyed studying in language, and at 16, he turned down a humanities-track undergraduate spot at Cambridge, one of the country's elite institutions.

Larbalestier, second from left on the bottom row, was the captain of his field hockey team at Imperial College in London.

"People wanted me to go on in a humanities vein, but I began to try and force myself onto a scientific track. Although I didn't want to go back to ancient languages, I found myself more and more interested in political, moral and societal questions than anything else. It took me a while to settle down into anything."

Larbalestier settled on a scientific-track at Imperial College in London, also an elite institution. His enrollment coincided with the explosion of music, arts and culture that was London in the 1960s, and he immersed himself in it. "I spent far too much of my undergraduate career involved in political matters and in music particularly," he said with a smile. "I think it was only in my senior year that I really turned on to my work and I became determined to go and get a Ph.D."

He earned a degree in Physical Metallurgy in 1965, and chose to conduct his graduate work at the same institution.

## Superconductivity catches fire

In 1964-1965, during Larbalestier's last year of undergraduate study, superconductivity was just emerging into public view, based on the possibilities unlocked by the 1962 discovery at Bell Labs of high magnetic field superconductivity in what very quickly became viable superconducting wires of Niobium compounds and alloys. These possibilities were energizing researchers everywhere.

During Larbalestier first year of graduate school, his adviser, who studied the properties of alloys (marriages of metals make much better superconductors than pure elements), was hooked.

"In that first year of graduate school, superconductivity transformed from this very interesting and more conceptual physics problem to something entirely new," said Larbalestier. "People went wild with the practical possibilities."

The phenomenon of levitation, now a commonplace demonstration of superconductivity's properties, proved irresistible for Larbalestier. "For me, in those days of course the levitation only existed as a picture in a book, but (seeing) it was amazing. I've never lost my enthusiasm for that."

Though he worked dutifully during graduate school, he found himself unexpectedly bored with the day-in, day-out process of obtaining data. During his project, his adviser left for an 18-month sabbatical in Berkeley, California, and except for the occasional letter, Larbalestier was on his own. His work, he said, attracted little attention from his peers or superiors.

As he navigated his project by himself, Larbalestier began to notice that something was amiss. The magnet he used for his superconductivity experiments gave inconsistent readings, and this inexplicable variation stymied his experiments and caused him to grow increasingly frustrated.

On a visit to Hangzhou, China in 1983.

Once Larbalestier discovered the problem, it changed both the direction of his graduate work and his attitude toward his chosen career path. He discovered that the magnet he'd been using for his experiments was made partly of a particular grade of stainless steel, one that became more and more magnetic with each exposure to magnetic fields.

"I began to focus more on the magnetic transformations in the stainless steel, and I found it very exciting. Frankly, I was bored stiff with the superconducting part of what was in my thesis," Larbalestier said with a laugh.

What was a potentially catastrophic and expensive mistake in magnet construction became both a learning opportunity and a chance for Larbalestier to take his thesis in a direction he found more promising. Armed with his new knowledge, he went to an Institute of Metals meeting in London, only to find a group of engineers at the British High Energy Physics lab (Rutherford Lab) planning to build an eight-tesla (powerful by the standards of the late 1960s) superconducting magnet swathed in the same stainless steel that had corrupted his experimental results.

Larbalestier had come prepared to speak on that very topic. "I got up and gave my little talk, probably very timid, and the guys said, 'My God, we've got to talk.' That started a relationship with the high-energy-physics community that has been absolutely continuous. They have been wonderful supporters for me and we've been deeply involved ever since," he said.

That intersection of two projects – one by a group of ambitious researchers, the other by a lone, disaffected graduate student– was one moment in many combinations of diligence and serendipity that have served Larbalestier well.

"My whole career has been sort of a lovely random walk, a response to opportunities that presented themselves at various points in time. If you're presented with several options and without fail choose the more difficult one, you will be rewarded for it," he noted.

## Blending research, teaching

By the mid-1970s, with his thesis and subsequent postdoctoral work in Geneva and London complete, Larbalestier, his wife Karen, and their children moved to Madison, Wisconsin, where he began a 30-year span as an educator and researcher, building a tight community of scientists and technicians around his work that has followed him to Tallahassee.

"Even now, there's a transformational aspect to superconductivity, a wonder, and around you forms a kind of culture of people who are just trying to do things that haven't been done before," he said.

As the years passed, his star rose in Madison, and awards, honors, and positions of greater responsibility followed. In 1981 he was named the associate chairman of Wisconsin's department of Materials Science and Engineering. In 1989, he was named director of the NSF-supported Materials Research Group in High Temperature Superconductivity, and in 1991 he was made a full professor and the director of Wisconsin Applied Superconductivity Center.

With wife Karen at Larbalestier's 2003 induction into the National Academy of Sciences.

All the while, Larbalestier was beginning to appreciate what for him was becoming an increasingly important relationship between his research and his teaching.

"What I realized is that you had this wonderful ability to take freshmen and sophomores while they were still open to this idea that education could be transformational. Then you could challenge them, get some of them to come and work in the lab and do really significant stuff while they were still undergraduates, and you know, some of these guys stayed with me. Others went on to Stanford or Berkeley or MIT. The light went on for them and it was: 'Yes, education is transformational and it's exciting' and essentially all I had to do was provide a culture and an opportunity for people like that, and they do wonderful things."

In the winter of 1983, materials scientist Peter Lee, still a principal investigator on the ASC team, joined Larbalestier. Lee echoes

Larbalestier's focus on blending research with educating the next generation of scientists, calling the most important accomplishment of the team "David's 31 Ph.D. graduates."

"David has a remarkable depth of understanding across the broad range of scientific disciplines that are needed in combination to make advances in the practical application of superconductors," said Lee. "It does not hurt that he is very, very, smart but combining that with his leadership and personnel skills make it both an honor and a pleasure to work in the group." Peter Lee added to David's capabilities in many essential ways, primarily by advanced electron microscopy and together they worked out many of the essential keys to pushing today's most practical superconductors, to their limits. In 1987, superconductivity at liquid nitrogen temperatures was discovered.

Eric Hellstrom was a newly hired assistant professor of ceramics and joined in to make and understand these still hotly studied and not yet understood materials. In the early 1990s, Alex Gurevich joined too, bringing a quite unique expertise in condensed matter theory and strong interests in applications of superconductors.

## The move to the Mag Lab

Though the Magnet Lab had offered once before, Larbalestier and his colleagues at the Applied Superconductivity Center didn't make the move from Wisconsin to Tallahassee until two years ago, when they felt that such a move would be compelling to both ASC and the Magnet Lab.

Pointing out that he is later in his career than his colleagues, Larbalestier was gratified that the lab agreed to move all of ASC rather than a handful of "starter" personnel.

"The wonderful thing about this new location is that the synergy is clearly here. You can see that superconducting magnets made of the high-Tc ceramics can become the next big thing. We've had amazing discoveries in the past six months. It's been an exciting time, even if for some of the younger people, a stressful one," he said.

At FSU, Larbalestier is still teaching for a semester each year – this term, a mechanical engineering class. He admits that engaging students in his field can be difficult and laments that in his current class of 40, there are no female and few minority

The celebration for Larbalestier's 31st graduating Ph.D. student, Matt Jewell, this past July.

students. Somehow, he says, interest in science and engineering is diminishing and narrowing, just at a time when the grand challenges of the world demand a much broader technical understanding of our highly connected and interdependent world.

"I think I was very well educated in the following sense – virtually all the teachers I had were interested in what they were teaching, and they wanted to pass on that interest. Students need to be persuaded to demand a lot of themselves so that their horizons expand, and not shrink in the crucial 5 to 10 years after graduation, when self teaching is the principal route to keeping fresh and up to date."

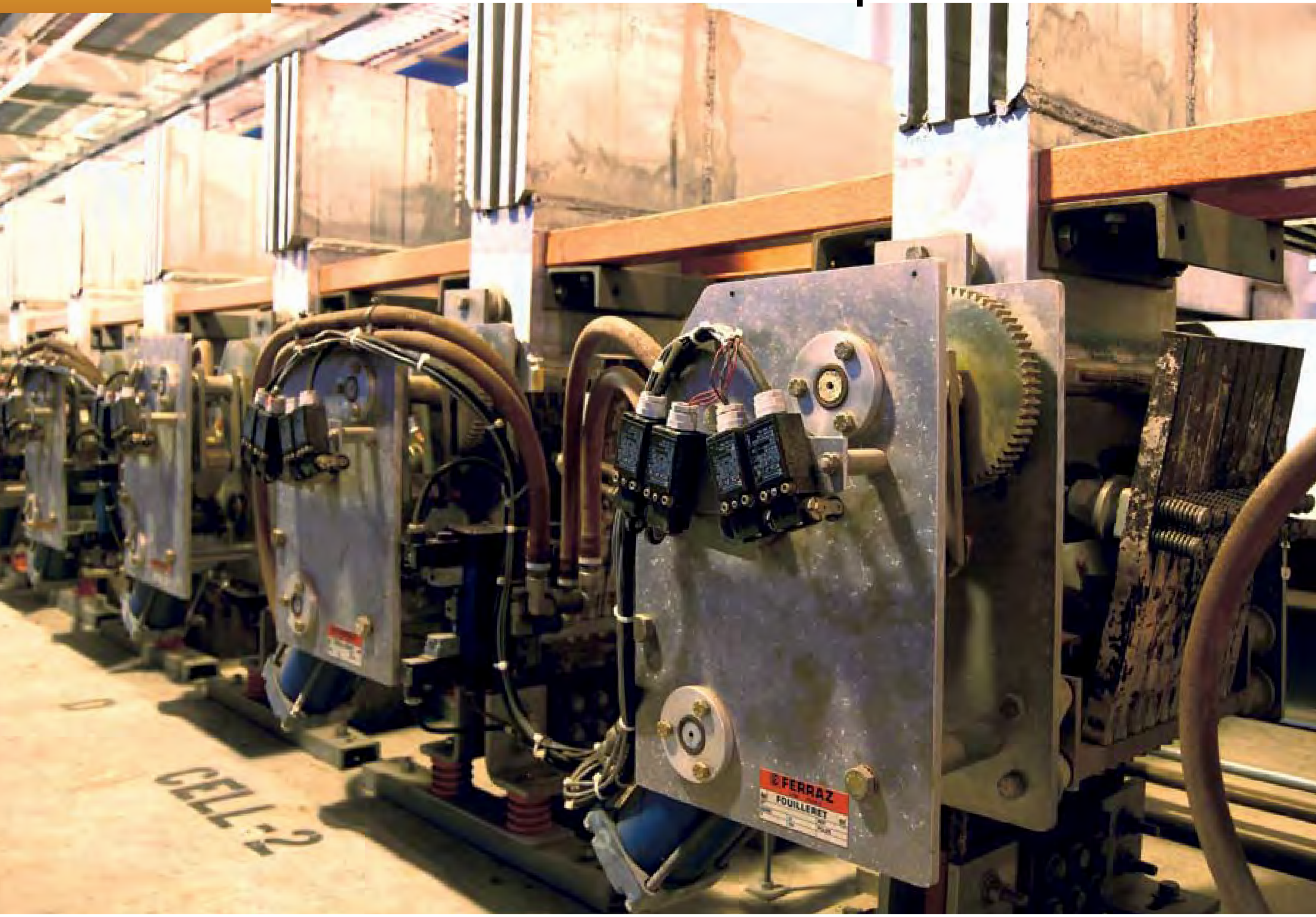
FSU, he says, is a "university with aspirations," a place where he feels that both lab and university leadership are willing to pursue meaningful, wide-ranging projects.

"This is an open, exciting culture that is actively trying to get more and more people to come and use the facilities and to collaborate. It's a very enviable environment," he noted.

And what of the original question, the superconductivity answer Larbalestier and his team have been chasing all these decades? Will he mind if a room-temperature superconductor is discovered long after he and his team are gone?

"If this discovery takes place, it is going to happen by accident, or it's going to happen by a stubborn and very individual act of invention on the part of one or two people," he said. "I'd love to see that, but on another level, I wouldn't mind if I don't, because I think the very complexity of life is one of the things that, looking back on life, is an opportunity for wonder."

# The bus room is one powerful station




Left: The view from the ground underneath the bus tunnel tracks.

**By Amy Mast**

Sure, it looks a subway tunnel for giants, and the Mag Lab's bus tunnel is used for transportation – just not the kind you're thinking of. This "bus" is a huge bar of aluminum that runs the whole length of the room – the central "tracks" you see in the picture on the right – and it carries electricity, not passengers.

You won't see the bus room on any public tour; in fact, it can't be seen from any of the main parts of the lab. It's actually on the second story directly above the row of magnet cells that ends at our biggest magnet, the 45-tesla hybrid magnet.

Each magnet has wiring that feeds into the bus tunnel. When a magnet is switched on, it's the bus tunnel's job to deliver the massive amounts of electricity required to power the magnet.

Right: The bus tunnel from end to end. For an idea of how big the room is, see the little dot on the wall at top right? That's a fire alarm box.

It's tucked away where no one can see it because nobody, and I mean nobody, wants to be in the bus tunnel when it's working. Consider a subway track, something we all know can kill you if you fall onto it. A subway track is powered with around 1.6 megawatts of electricity. Compare that to the 56 megawatts of energy the bus tunnel is capable of moving, and you'll understand why this is a room with four alarms.

The switches that control the movement of electricity from the bars down into the magnets are at floor level; there are 128 of them that have to be monitored and maintained for the system to work properly. Sound complicated? It's just one of the many processes supervised by the control room operators who keep the magnets constantly fed with electricity and magnet-cooling water.

# Learn how to reveal the iron hidden in your food

**By Kristen Coyne and Amy Mast**

You may think of it largely in terms of lawn furniture and vitamins, but iron is everywhere. Not only is iron the fourth most common element in the earth's crust, it's also an essential part of our own blood.

Many foods contain iron, which blood cells need in order to carry oxygen. A protein called heme contains the iron (II) ion at its center. Blood vessels in the lungs, where oxygen concentration is high, allow the heme to bond to the oxygen molecule to create oxyhemoglobin, which is then transported to oxygen-hungry tissues throughout the body.

Because iron is so important to your body, you need to make sure you get enough in your diet. You may have heard about meat and spinach being rich in iron (what do you think made Popeye so amazingly buff?) but it's found in many other foods, including most breakfast cereals.

Iron is naturally magnetic, and even though your blood contains iron, you can't get a refrigerator magnet to stick to you. That's because the iron in your blood is spread out into particles too small to get the magnet to react.

You can, however, use a magnet to separate the iron contained in some iron-rich foods. Who knew breakfast could be so delicious and so magnetic?

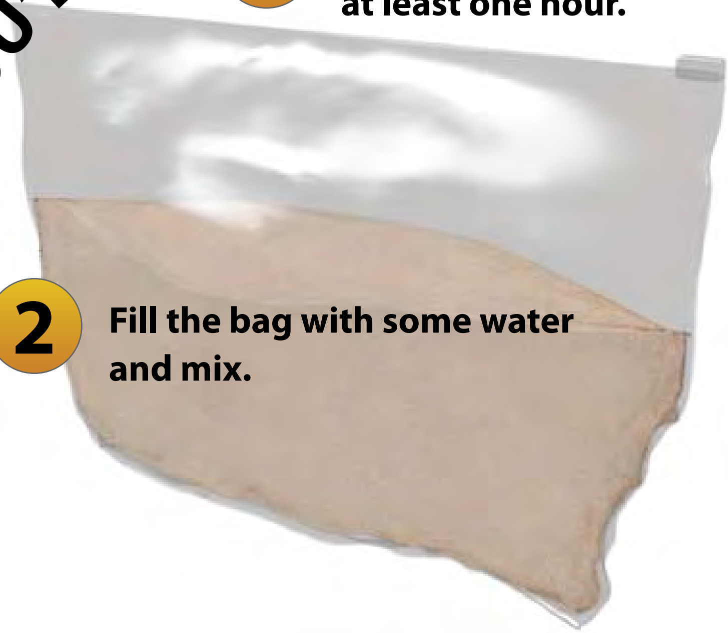
## What you'll need:

- Cereal or other food with iron (Total Cereal or Gerber Graduates Arrowroot Cookies work great)
- A Ziploc bag
- A little water
- A plastic, see-through cup
- A magnet

## WHAT YOU'LL DO:

**1** Pour some of the food into a Ziploc bag. Seal the bag with as little air in it as possible, then mash the food until you make a powder.

**2** Fill the bag with some water and mix.



**3** Let the mixture sit for at least one hour.

## DID YOU KNOW?

- *People without enough hemoglobin in their bloodstream are called anemic. The most common symptoms of anemia are weakness and fatigue.*
- *All of the blood in your whole body contains about 2.5 grams of iron – about the weight of a single penny. It's amazing that such a small amount can be so important!*
- *Breathing carbon monoxide (such as car exhaust) is dangerous because it binds to the iron in the heme molecule about 200 times tighter than oxygen does. This kicks those needed oxygen molecules out of the way, possibly leading to suffocation.*
- *How much iron you need in your diet depends on your age and gender. Teen and adult women need about 15 milligrams a day. Teen and adult men need about 10 milligrams a day.*

**4** **After the cereal mixture has been allowed to sit, pour some into a plastic cup.**

**5** **Move a strong magnet against the side of the cup for about a minute. You should observe iron particles collecting on the side of the cup!**

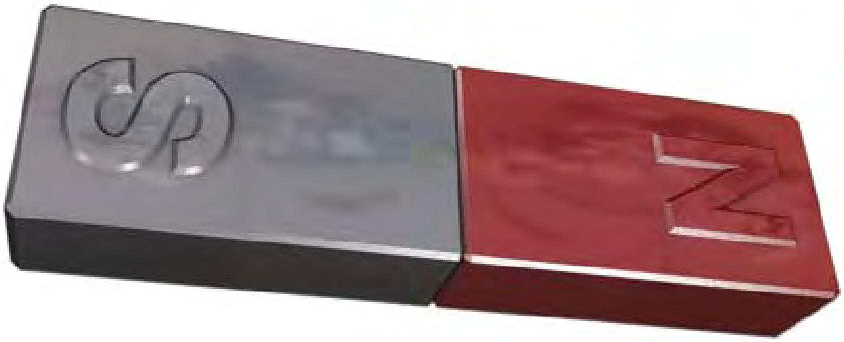
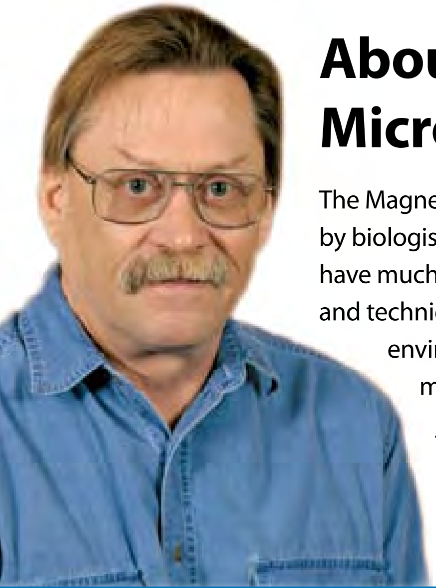



Illustration by Kevin John

# Mag Lab Image Scramble

## Challenge:

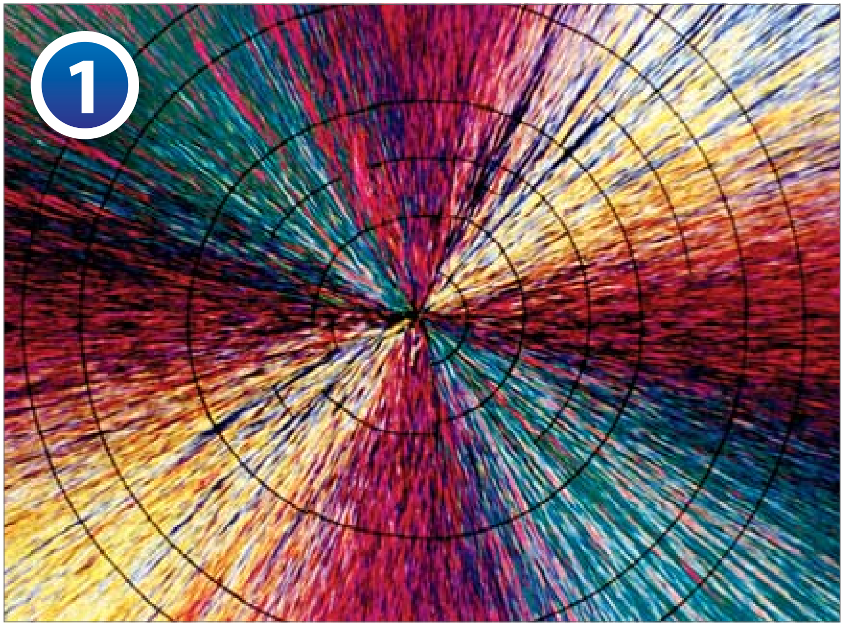
See if you can match these super detailed views of familiar items with their proper names. The images, captured by the Magnet Lab's optical microscopy group, range in magnification from 40 to 1,000 times their original size.

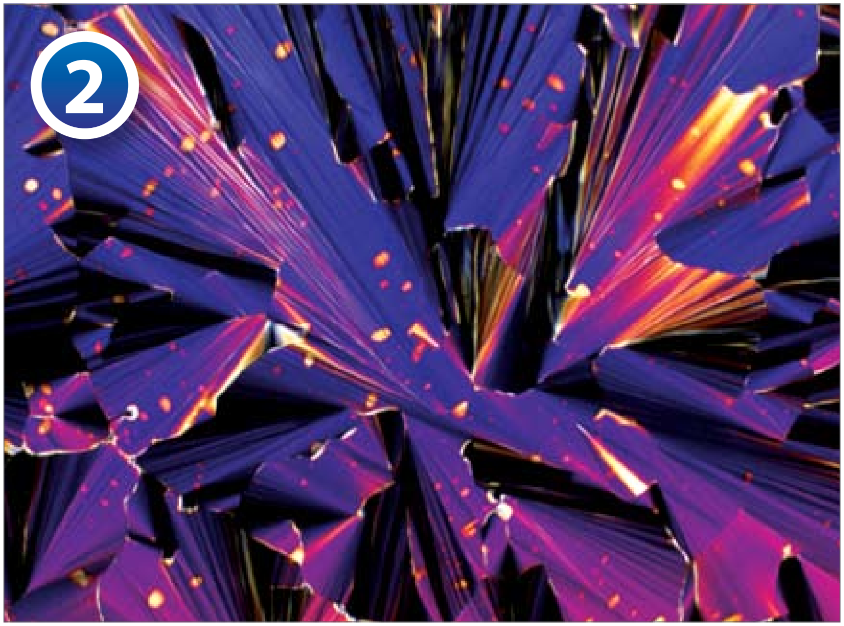


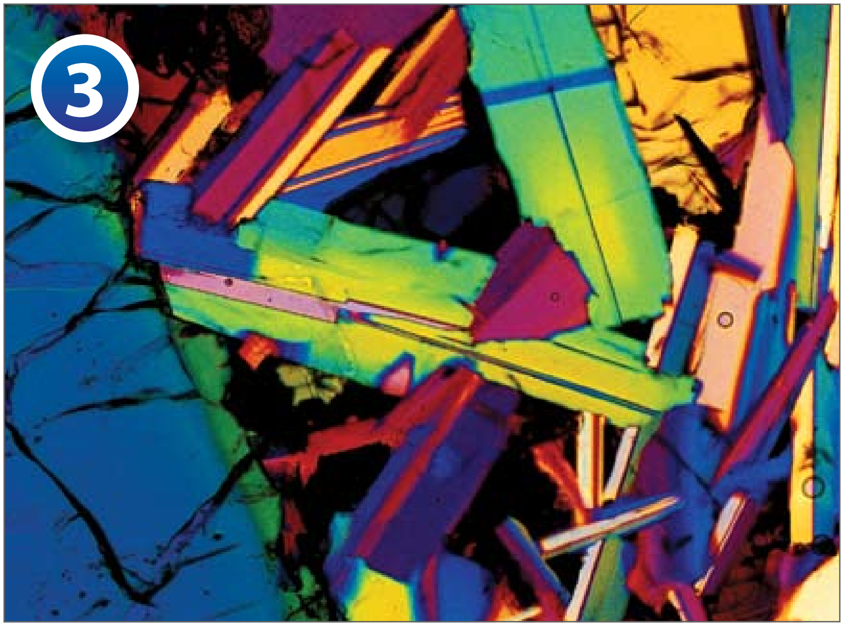
## About the Optical Microscopy group

The Magnet Lab's optical microscopy group, led by biologist Mike Davidson (left), doesn't really have much to do with magnets. So why is it here? Great science often happens where seemingly unrelated disciplines and techniques converge. Affiliated research programs such as optical microscopy enhance the lab's rich collaborative environment and lead to novel collaborations. The group also strongly supports the lab's education mission, mentoring students and teachers through the lab's Research Experiences programs.

The work of the Davidson team has appeared everywhere from *Wired* to *Nature* to textbook covers and album artwork for about 50 bands of all persuasions (from rock to gospel).





## Liquid crystalline DNA

Textbook drawings of a double helix don't really cover it, do they? Though scientists often study DNA in a dilute solution, this sample is in highly concentrated liquid form.

## Steroid hormones

You may think of steroids in terms of bodybuilders and syringes, but steroid hormones like those in this image occur in our bodies naturally.

## High temperature superconductor

This is a lanthanum aluminate wafer - a ceramic material that is used as a solid support for testing fragile thin film superconductors.

## Moon rocks

Not so gray and boring up close, are they? This is a volcanic lava sample collected by Apollo 12 astronauts, one of 2,196 samples collected by the team.

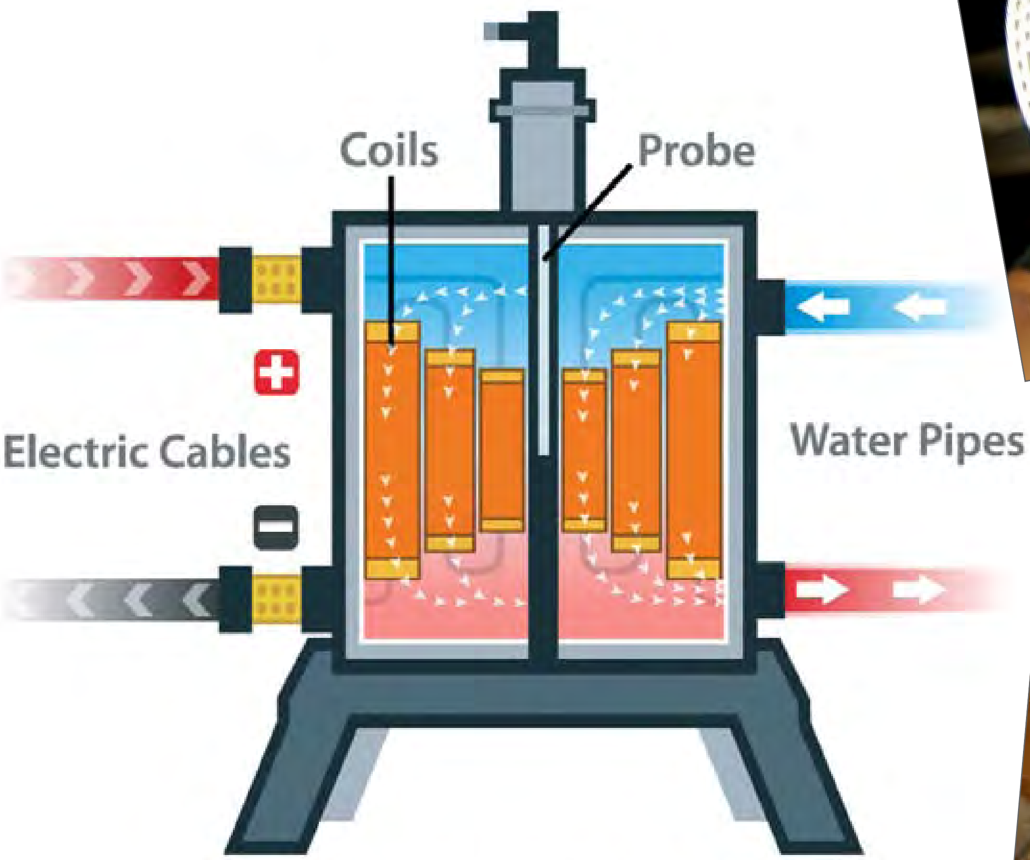
*1. Steroid hormones*
*2. Liquid crystalline DNA*
*3. Moon rocks*
*4. High temperature superconductor*

# BUILDING A RESISTIVE MAGNET COIL

**Photos by Kristen Coyne**

You won't see it on the tour, but resistive magnet coils are key to the high magnetic fields created at the Mag Lab.

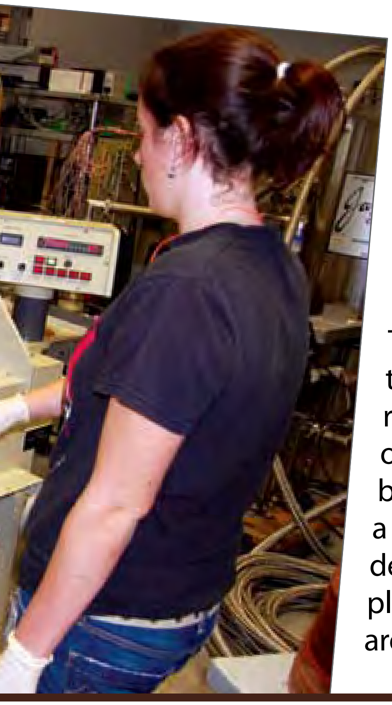
Resistive magnets are electromagnets, meaning they create a temporary magnetic field with the same electricity you use at your house — just with a whole lot more of it. When the electricity is turned off, so is the magnetic field. We build the coils right here at the lab.




**RESISTIVE MAGNET**
(cross section)

Magnet technician Nicole Walsh inspects a Florida Bitter plate. The plates are stacked atop one another to form coils. Every plate is checked repeatedly as the coils are constructed; a single crack or flaw in the coil's construction can ruin the whole thing. To learn more about Bitter plates, see page 16.

The completed coils stack inside one another like Russian dolls to make the strongest field possible.



This machine smooths the Bitter plates to remove rough spots or imperfections left behind from stamping, a process known as deburring. Once the plates are flawless, they are stacked to form a coil.

This is an illustation of the innermost coil of a resistive magnet.

Illustration by Kevin John

# Kitchen takes an unconventional road to research

**By Amy Mast**

*Jason Kitchen, a member of the lab's nuclear magnetic resonance probe-building team, husband, father, and Florida State University undergraduate, proves that the road to research can wind a little along the way.*

Jason Kitchen assembles a probe. Latex gloves keep the delicate parts clean.

The Magnet Lab employs people with many types of degrees. Physics, engineering, math and chemistry degrees, sure. But anthropology?

Mag Lab employee and FSU engineering major Jason Kitchen's path to a career in science has been an unusual one. Kitchen graduated from FSU in 1997 with a degree in anthropology and headed out west to New Mexico, where his natural aptitude in other areas led him to a job as a database manager for a defense contractor.

Growing up, Kitchen liked both anthropology and engineering, but he chose the former for his first degree.

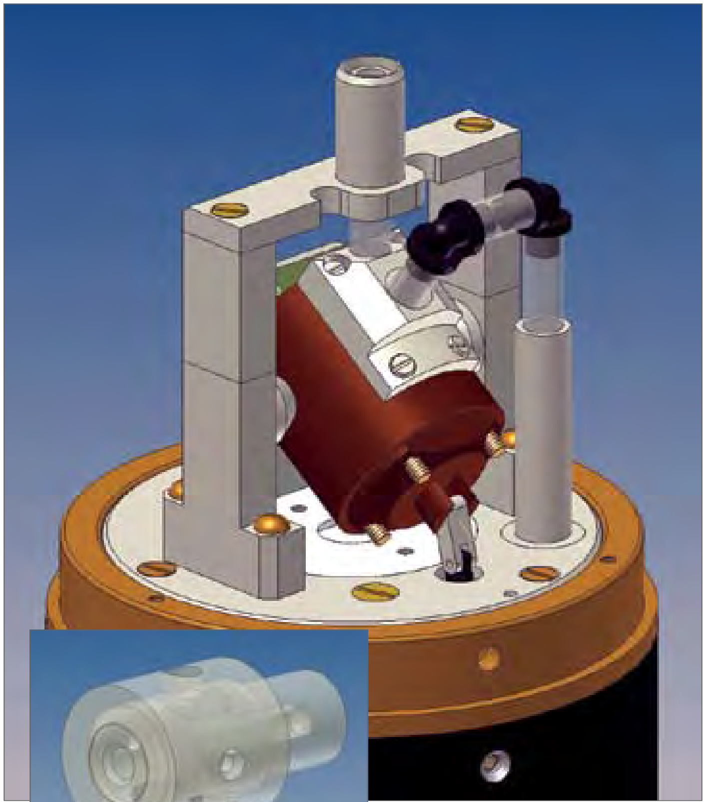
"By the time I got done with the degree, I didn't think I wanted to go on to graduate school and do (anthropology) as a career," said Kitchen. "I missed working with my hands, and I always liked science a lot."

Other people at the defense company noticed Kitchen's scientific bent, and he was soon splitting his time between the database work and the more exciting field experiments engineers were conducting. "Seeing the mechanical engineers do the computer-aided design (CAD) work tied in with how much I like to draw and I like 3D visualization," Kitchen said.

On a visit to see his brother in Tallahassee, Kitchen met his now-wife. As their long-distance relationship grew, he made the decision in 2004 to move back to Florida and get married. With the move, he took the chance to go to college all over again – this time with the goal of an engineering degree squarely in place.

His new degree underway, he applied for a part-time position in the Mag Lab's Geochemistry department. Sure, it was a job pushing papers, but it represented one step closer to the type of work he wanted to be around. He began to do some bookkeeping work here and there for other departments until he found himself in a conversation with Associate in Engineering Peter Gor'kov, part of an innovative lab team researching, designing and building magnet probes for nuclear magnetic resonance (NMR) experiments.

"I told Peter that I was a mechanical engineering student. He kind of raised his eyebrows and said, 'What are you doing in administrative position?' So the next time we met, I showed him some of my CAD drawings. He showed them to the machinist, Richard Desilets," said Kitchen.



Some of Kitchen's CAD drawings have made their way from concept to reality.

Desilets was impressed, and Kitchen embarked on a new adventure. While he continues to do some administrative work for the group, he also produces CAD drawings and helps to assemble probes. During the day, Kitchen simply walks from his job at the lab to his engineering classes across the street and back again.

"Jason was a real find," says Associate Scholar/Scientist William Brey. "I admire the way he manages his life so that he can excel in his classes, be an engaged father, and still arrive every day and focus on his work at the Mag Lab."

Working on probes is detail-oriented, complex, and time consuming, says Kitchen, and having a mentor like Gor'kov has taught him some important lessons.

"In addition to being a scientist, Peter's got a strong aesthetic sense," said Kitchen. "I think he feels things will work better if they are also beautiful – if they look just right. I appreciate the time he takes to do things right; instead of spending all our time troubleshooting what's wrong with a probe you can give that time to serving a user need."

Once his degree is complete, Kitchen's goal is continue working in the same field, citing the combination of discipline and inventiveness as the reason that this work, for him, is finally the right fit.

# Stuck on you: Fear not, magnets won't suck you in

**By Amy Mast and Susan Ray**

While we may have the biggest magnets in the world, you don't need to worry about flying through the air and sticking to the magnet by your jacket zipper or your fillings. The super-strong fields we create are directed at and contained inside the bore, or experimental space, at the magnet's core. Around the magnet there's a much smaller magnetic field (called a fringe field), though it's still higher than the one you'd experience walking down the street.

When you tour the lab, you'll see painted lines on the floors in the magnet experimental areas, or cells. These are called gauss lines. The line our visitors stand behind is a blue "10 gauss" line. As long as you don't go beyond that line (and we make sure you don't) your credit cards, cell phone and other electronics will be fine. Credit cards store information on magnetic strips. If you got too close, that information could be erased! You'd also be OK behind the 10 gauss line if you have a metal implant or joint or insulin pump.

You'll notice that there are no wrenches, screwdrivers or other tools near an energized magnet. Suppose you snuck past the 100 gauss line holding a metal thermos or digital camera. That might get sucked out of your hand, provided the magnet is running at a high field, but your feet would not leave the ground.

Below and right:
Visitors won't get sucked into a magnet, but a high-field magnet such as the 45 tesla hybrid will cause this metal staircase to temporarily turn into a magnet, which explains why these tools can stick to it.

**FACT**

▷ *An MRI machine has a magnetic field of around three tesla. If you've been inside one of those, you've experienced a higher magnetic field than you will during a tour of the Magnet Lab.*

# See for yourself

***Whether you go in for big parties, small get-togethers or a virtual experience all your own, there are lots of ways to learn about the Magnet Lab.***

## Magnet Mystery Hour

What do magnetic levitation, cleaner oil, and the biggest electric bill in Tallahassee have in common? Find out at the Magnet Mystery Hour (and ask us whatever you want) when scientists present their work in everyday terms.

The Mystery Hour is an ongoing series of lectures aimed at educating the general public about the lab's research and providing direct access to working scientists. The first lecture, held Sept. 16, featured lab Director Greg Boebinger, who provided an overview of electricity and magnetism. In case you missed it, you can watch the presentation – which includes a demonstration of magnetic levitation – online at www.magnet.fsu.edu/education.

### Future Magnet Mystery Hours include:

- *November 2008 – David Larbalestier, director of the Applied Superconductivity Center, will talk about new materials with super powers.*
- *January 2009 – Sam Grant, an assistant professor at the FAMU-FSU College of Engineering and member of the lab's Nuclear Magnetic Resonance group, will explain how MRI came to be, and what it could be used for in the future.*
- *April 2009 – Scott Hannahs, director of DC Facilities & Instrumentation and well-known skeptic, will address magnet myths and take your questions, no matter how crazy they might be.*

All talks take place at the Magnet Lab in Tallahassee's Innovation Park, room B101. For upcoming dates and more information, call (850) 644-1933 or visit www.magnet.fsu.edu/education/

## Get schooled without leaving your desk

Ever wondered how Mag Lab magnets work or what they're good for, but figured you might not understand the answer? Fear not, right-brained friends: We tackle these and other questions about our lab, electricity and magnetism at Mag Lab U, an online resource created for non-scientists.

You don't need a Ph.D. – or even a bachelor's degree – to understand these lessons. Mag Lab U makes scientific concepts accessible with jargon-free writing, pictures, interactive tutorials and audio slideshows designed not to scare off English majors.

You won't find tests, but you will find cool content exploring our work, our instruments and the science behind them, including:

- *Articles on superconductivity, cryogenics, MRIs and magnet operations.*
- *Interactive tutorials on everything from compasses to current flow.*
- *Audio slideshows that bring you deep inside the lab to see and hear how magnets are made and how the world's strongest magnet works.*

Visit Mag Lab U at
www.magnet.fsu.edu/education

Lab Director Greg Boebinger demonstrates the Meisher effect at Magnet Mystery Hour.

## Save the date: Magnet Lab Open House

On Feb. 21, 2009, the Magnet Lab will once again host the biggest, baddest and best science ticket in town: the annual Open House. If you haven't fired a potato cannon, seen a quarter shrink to the size of a dime, watched liquid oxygen glide through the air, or made lightning in a bucket, this is your year. And if you have? Well, you know you want to do it again.

Electronics engineer Andy Powell demonstrates a Tesla coil at a recent Open House.

For 2009, we're devoting our large conference area to hands-on children's activities. But rest assured, the Open House is geared toward all ages, and those interested in tensile strength, phase transitions and coil windings can get their fill.

The fun starts at 10 a.m. and continues until 3 p.m. For more information, visit the Open House Web page at www.magnet.fsu.edu/education/community/openhouse

## Tours are not just for school groups

Free tours of the lab are available during the workweek for groups of eight or more, but they must be scheduled at least three weeks in advance. Tours last about an hour, with scientists, educators and staff providing perspective on the cutting-edge research conducted at the laboratory. Tours include a general overview of the Magnet Lab and the research conducted as well as explanations of the different types of magnets used, including resistive magnets, superconducting magnets, pulsed magnets and our world-record hybrid magnet.

Although the lab hosts many school groups, tours for the general public also are available.

Of course, school groups are more than welcome – and encouraged! The lab offer special tours for student groups that include a hands-on learning activity. To schedule a tour, contact Felicia Hancock at hancock@magnet.fsu.edu or (850) 645-0034.

**-Flux staff reports**

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1800 EAST PAUL DIRAC DRIVE
TALLAHASSEE, FL 32310-3706

TEL: 850 644-0311
FAX: 850 644-8350
*www.magnet.fsu.edu*

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