Hiding in a UW basement, huge magnets

These are not the magnets your mom used to hang your homework on the refrigerator

By Lauren Michael
THE DAILY CARDINAL

When wondering what goes on in the basement of UW-Madison's science buildings, a few possibilities come to mind: Discarded lab gear? Experiments gone awry? A professors-only fight club?

In the Biochemistry Addition building, what's lurking down below turns out to be highly beneficial to research across the country and to the university's research reputation. It also makes use of some of the largest magnets in the world.

Most UW-Madison students are probably unaware of the multimillion-dollar resource housed in the lowest floors of Biochemistry. However, the National Magnetic Resonance Facility at Madison (NMRFAM) is a vital component of local and national science.

Data collected at NMRFAM has been used to understand molecules important to many biological processes and diseases. In 2008, the facility even helped to resolve a worldwide contamination of the blood anticoagulant, heparin, that affected nearly 1000 people in the United States alone, according to the Food and Drug Administration.

NMRFAM was established at UW-Madison in 1985 and is fully funded by a $10 million grant from the National Institutes of Health. It now houses 11 machines used by researchers in 24 states and four other countries. More than 80 researchers on the UW-Madison campus alone have used the facility in the last year.

The technique is known as nuclear magnetic resonance (NMR) spectroscopy and requires extremely strong magnets. So how does it work?

You're probably familiar with magnetic resonance imaging, or MRI, which is derived from NMR. Scientists and doctors just took the 'nuclear' out of the MRI title to avoid undo fears of nuclear radiation. Actually, neither technique uses radiation at all. Instead, NMR talks to the nuclei of atoms using radio waves.

When molecules are placed in a strong magnetic field, each atom's nucleus aligns with the magnetic field. When aligned nuclei are hit with a radio wave, they emit a new radio signal back.

"It's as if each atom in a molecule has become a unique radio station," explains Dr. Larry Clos, II, research associate at NMRFAM. By listening to the radio stations broadcast by every atom, NMR scientists can determine details of molecular structure.

For MRI scans, this information is used to construct an image of tissues and organs. However, the details of molecular structure revealed by NMR require much stronger magnets than those in MRI machines.

Most MRI magnets are as strong 0.2 to 1.5 tesla—a tesla is a unit of magnetic strength named for scientist Nikola Tesla in the 1960s. The NMR magnets at NMRFAM are as strong as 21 tesla, equal to about 4200 refrigerator magnets or 680,000 times the magnetic field of earth.

So how are such strong magnetic fields generated? Magnets in NMR machines are made of metals that become superconducting magnets when cooled to extremely low temperatures. A thermos-like design and cryogenic liquids keeps the temperature of each NMR magnet at only four degrees above absolute zero (that's -452 degrees Fahrenheit).

The machines at the UW-Madison facility, in combination with many smaller NMR machines scattered about UW science labs, have secured the university's standing as an internationally ranked site for NMR resources and research.

The facility certainly serves as a significant contributor to UW-Madison's reputation as a major research university. Multiple UW-Madison labs have built strong reputations for specializing in NMR methods. These labs draw significant funding, international collaborations and top scientific minds to the university.

Perhaps best of all, NMRFAM's reputation and its benefits to UW-Madison are achieved without any expense to the university itself. In fact, 40 percent of the grant that funds NMRFAM goes directly to university resources. The remaining funds and user fees cover personnel and operating costs.

There are a variety of resources like NMRFAM concealed in the science buildings of the UW-Madison campus. Most students will never realize how much the quality of their degrees benefits from these facilities.

PHOTO COURTESY DR. LARRY CLOS, II

NMRFAM's largest supermagnet machine, at 21 tesla, looks like a spaceship and can fill a two-story room.

Balloons, gravity and runaway helium

By Lee Bishop
THE DAILY CARDINAL

Did you ever wonder what happens to helium-filled balloons when you let them go? Well, as they fly up into the sky the atmospheric pressure drops, so the balloons grow larger. Eventually they pop, releasing their helium and falling back to Earth.

But what happens to all the helium? It keeps on rising and never stops!

Helium atoms are so light that Earth's gravity can't hold them, so they float away into space. This is why earth, compared to the rest of the solar system, has a miniscule amount of helium.

Helium is the second-most abundant element on Jupiter and Saturn—planets over 100 times as massive as Earth. In fact, they have enough mass that their gravity keeps the helium from being blown away by solar winds.

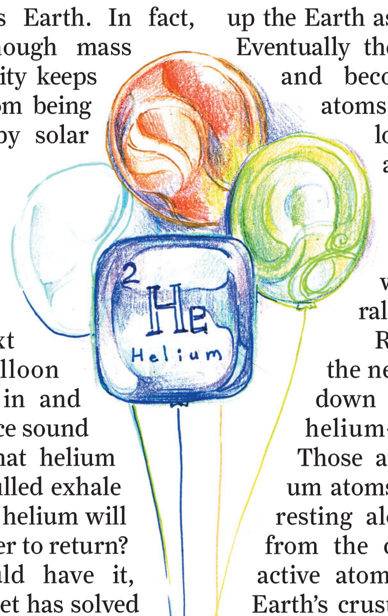
But this creates quite a quandary when you want to open up the next helium balloon to breathe it in and make your voice sound funny. Isn't that helium and laughter-filled exhale precious if the helium will float away never to return? As luck would have it, your own planet has solved this problem quite well. Earth is a veritable helium factory, so exhale freely!

If you paid attention in middle school science class you probably remember that matter can never be created or destroyed. So, you're probably wondering how our own planet can produce helium atoms.

Never fear, though. Earth is not violating the laws of nature. It is actually producing helium atoms as a by-product of the nuclear breakdown of radioactive uranium and thorium atoms that have been in the earth's crust ever since its formation.

When these unstable atoms decompose, they spit out tiny, fast-moving things called alpha particles. These speedy particles bounce around, heating up the Earth as they slow down. Eventually they grab electrons and become the helium atoms we know and love. These helium atoms collect in Earth's crust and are pumped out of the ground with oil and natural gas.

Remember this the next time you stroll down the street with a helium-filled balloon: Those are newborn helium atoms in your balloon, resting along their voyage from the centers of radioactive atoms, to pockets in Earth's crust, to your balloon and finally off into outer space.



ANNIE E/THE DAILY CARDINAL

UW computer models weather patterns

By Aaron Schumacher
THE DAILY CARDINAL

If a butterfly flaps its wings in Brazil, will a hurricane destroy Florida? If a satellite sees clouds in Nevada, will it mean rain for crops or mud slides down mountains? Questions like these need a computer with real muscle, run by the best people, and that's what UW-Madison now has.

The S4 supercomputer built on campus this year is now fully operational and the most powerful resource of its kind at the university's disposal. It's working to fully incorporate data from satellites in models of the Earth's oceans and atmosphere—data that could help improve our understanding and forecasting of these complex systems.

Just how powerful is the new supercomputer? Well, it's gotten harder to make computer processors faster, so engineers are placing more than one computer brain or "core" on each chip. Even your iPhone has two cores that work together to send text messages as quickly as possible. A new iMac has four cores on its single chip, for blazing fast Facebook rendering.

The processors in the new supercomputer at UW-Madison's Space Science and Engineering Center (SSEC) each have 12 cores per chip, while a typical desktop has only one. There are four of these chips in each unit.

Oh, and there are a whopping 64 of these units working together in the S4, keeping track of a multitude of data and grid points over the Earth's surface. In terms of RAM, the working memory of any computer, the S4's processing units alone have over 2,000 times what you'd find in an iMac.

This speedy behemoth fills up five ceiling-high racks in the 1225 Dayton St. building. There are 26 more computers serving as the collective hard disk, providing a total of 456 terabytes in storage space.

To fund the construction of the S4 supercomputer, the SSEC received a grant of $1 million from the National Oceanic and Atmospheric Administration (NOAA) earlier this year. This decision was made in favor of UW-Madison largely because computer engineers on campus have the special skills to create such extreme computing systems.

The S4 supercomputer project extends a collaboration between the NOAA and UW-Madison's SSEC. NOAA researchers, including many at UW-Madison, use the supercomputer for important computationally complex tasks.

The S4 supercomputer is a powerful new resource on campus. Its availability to researchers will help advance atmospheric and oceanic modeling techniques for national applications and will expand the capabilities of UW-Madison researchers working on many other projects.

Ask Mr. Scientist

Dear Mr. Scientist,
How is it that I can wear shorts when it is 65 degrees outside, but water that's 65 degrees feels freezing cold?
—Julian G.

Everything including water, air and your skin, is made up of molecules that are always moving around, vibrating and bumping into things. Your skin is about 98 degrees, so skin molecules have more energy than air or water molecules that are only 65 degrees. When one of these colder molecules bumps into your skin, energy is transferred to the colder molecule causing your skin to be a little bit cooler and the material that touched you to be a little bit warmer. Since water is more dense than air, more water molecules continually bump into your skin, stealing more energy and making you feeling colder.

Dear Mr. Scientist,
Is it true that no two snowflakes are exactly alike?
—Nick M.

All snowflakes start out in the clouds as simple hexagonal prisms. Once in a while, snowflakes reach the ground as this basic shape, so finding two identical snowflakes of this kind is possible. When snowflakes start to grow, however, they rapidly distinguish themselves from one another. It is estimated that a snowflake has over 10 quintillion water molecules that can be arranged in nearly an infinite number of ways. While some snowflakes may look similar, it is close to impossible for two snowflakes to be exactly the same.

Mr. Scientist is Michael Leitch. If you have a question you want him to answer, e-mail it to science@dailycardinal.com.