Chemical Eye On

Contributed by Preston MacDougall

Click here to read a previous Chemical Eye On

Chemical Eye on Synthetic Biology

He represented a literary breakthrough for Mary Shelley, and commercially, Frankenstein's monster has been a worldwide success for almost two centuries. Source: morguefile.comDr. Victor Frankenstein, the Promethean protagonist that Mary Shelley created out of words in the early 1800s, has been back in the news lately.Â Â But this time only letters were used - As, Cs, Gs and Ts, the nitrogenous bases that are in our DNA--and the creature is not a giant but a microbe.

On May 20th, the journal Science posted online the historic account of how the research team led by thrill-seeking biochemist J. Craig Venter, whose life and science are boldly told in his autobiography A Life Decoded , had succeeded in designing and synthesizing the genome of an entirely new species of bacterium.Â There is nothing microscopic, however, about the storm of legal, ethical, and even moral controversies that this scientific breakthrough has created.Â

I imagine the atmosphere at the J. Craig Venter Institute in Maryland must have been absolutely electric when they realized "It's alive!" and was reproducing as bacteria normally do.Â

The cell created by Venter's group was made by putting the new, purely synthetic DNA molecule containing 1,077,947 base pairs (which required a complex multi-stage assembly, not unlike that used to collaboratively compete very large jigsaw puzzles), into an unrelated bacterium that had all of its DNA removed.Â And after months of normal bacterial life - digesting and dividing--there remains virtually no trace of the original host cell in the colony of the new organism.Â That is simply amazing to me.

I am sure that it is equally frightening to others.Â For two centuries now, Frankenstein's lab creation has been the poster child for science run amok, and there has been no shortage of Internet villagers angrily condemning Venter for playing god and creating an artificial organism that could have unimaginably devastating consequences if it escaped - just like Frankenstein's monster did, not to mention the dinosaurs in Jurassic Park.

In actuality, there are no dangers posed by Venter's creation that we have not been living with since 1972.Â That was when other American researchers--mostly biochemists and in the San Francisco Bay area--invented recombinant DNA as a chemical means of genetic engineering.Â The fruits of this earlier scientific breakthrough--as well as the vegetables, medicines, oil-eating microbes and all sorts of other products and processes--have become economically extremely important since then.Â

The World Wide Web didn't exist in 1972, but the ethical and environmental concerns raised by genetically modified organisms were raised then almost as quickly as they have been since Venter's announcement a few weeks ago.Â By 1975, researchers in the field, all very eager to explore and expand the scientific possibilities of genetic engineering, had voluntarily agreed to establish safety measures and means of regulating the new biotechnologies.Â This became known as the Asilomar Conference, after the seaside state park in California where the conference was held.

As far as I know, the biochemists and biologists who met at Asilomar did not feel like they were playing god when they manipulated the DNA of microbes.Â Do Poodle breeders have qualms when they do essentially the same thing with dogs?Â The conferees knew they had to be very careful; so do bomb squads.Â The idea that there is a vital force that distinguishes living matter from inanimate matter is as old as medicine.Â But the electro-chemical discoveries of Alessandro Volta were of recent renown in Europe when Mary Shelley imagined her monster, and I suspect that this may have been her inspiration for the "spark of life" that Dr. Frankenstein tried to recreate.

Judging by how things turned out for Dr. Frankenstein, I don't think Mary Shelley and Craig Venter would have good chemistry between them.Â We can't test that theory, even with the most advanced cloning technology, but I would be interested to know if she ever met or read about her contemporary Friedrich WÃ¶hler, and what she thought of the WÃ¶hler synthesis in 1828.

WÃ¶hler was the German chemist who first synthesized a type of living matter from inanimate materials--organic from inorganic.Â Most famously, he synthesized indistinguishable samples of urea, which is a main component of our urine, from ammonium cyanate crystals, which were themselves obtained by reactions of rock stable minerals.Â If I had been around at the time, that would have been simply amazing to me.

Within a few decades, the newfound power of synthetic organic chemistry revolutionized industry and later medicine in Europe and America.Â I don't think it will take anywhere near that long for synthetic biology to bring our economy back to life.

Preston MacDougall is a chemistry professor at Middle Tennessee State University. His "Chemical Eye" commentaries are featured in the Arts and Public Affairs portion of the Murfreesboro/Nashville NPR station WMOT (www.wmot.org).

Click here to read a previous Chemical Eye On

Chemical Eye on Oil and Water

Source: Facebook.com
The Grand Ole and water don't mix either, but they are easily parted when artists are determined and alternative venues are generously offered.
Here's something you don't see on live TV every day â€“ a portable classroom was submerging into eastbound traffic that was bobbing up and down on I-24 between Nashville and Murfreesboro.

As surreal as that image was, it was just the beginning of a historic two-day monsoon that literally swamped large portions of Middle Tennessee, drowning ten people just in Nashville and dissolving untold amounts of uninsured home equity.

Water is an incredible solvent, for instance it can dissolve more than its weight in sodium hydroxide, also known as lye or caustic soda.Â But it can't dissolve mineral oil, hence the saying that oil and water do not mix.Â They don't mix in a test-tube, and apparently they don't mix very well on the boob-tube either.Â I say that because while Nashvillians were swimming for their lives across interstates, the nationally televised news coverage was focused on the tens of thousands of barrels of oil â€“ per day - that were gushing out of a ruptured well on the floor of the Gulf of Mexico, with no end in sight but the delicate estuaries of Louisiana ominously down-current.

While the water was rising in Nashville, there was another big story breaking in New York City.Â The unexploded car-bomb found in Times Square, and the Connecticut jihadist who put it together, were headline news in print and on TV for days.Â This story, unlike the water-based one, seemed to easily blend with headlines about the oil-gusher in the gulf.Â Perhaps the chemical metaphor explains this better than the regional bias that was widely blamed by Tennessee bloggers: The Times Square would-be bomber had ties to Pakistani Taliban, who are in league with al-Qaeda, which has the Saudi Osama bin Laden at its head.Â In other words, the bomb story was oil-based.

To get back to chemistry, oil and water don't mix, but they do form an emulsion.Â And that's where Anderson Cooper comes in.Â He brought the attention of mainstream news to the floodwaters of Nashville, even while the gushing in the gulf seemed to worsen.

Anderson Cooper has also done wonders for the hair gel industry, but gels are structurally different than emulsions.Â Gels have "body" because they contain very long polymer molecules that are cross-linked with each other, forming a kind of scaffold at the nano-scale.Â The many pores can be filled with compounds that have either cosmetic or medicinal purposes.Â They can also be left empty, as in aerogels that can be made into curious solids that are lighter than air and described as solid smoke.

Emulsions on the other hand, are homogenized liquid mixtures made from two or more immiscible liquids, such as oil and water.Â For instance, olive oil and vinegar, which is mostly water, form an emulsion when shaken vigorously.Â You might call it salad dressing, but I call it chemistry, which is my bread and butter.Â If you let this mixture sit for a while, it will separate into two liquids, with the oil layer floating on top.

To prevent this from happening, or to stabilize the emulsion, surfactants are added to the mixture, and this is the only purpose of many of the odd-sounding ingredients that you see on bottles of salad dressing or shampoo, such as sodium laurel sulphate.Â Without going into much chemical engineering, these surfactant molecules like being at the interface of the two immiscible liquids, but try to keep their distance from each other.Â

Until the gushing of oil could somehow be stopped in the gulf, one of the methods initially used to mitigate the environmental catastrophe that would occur if large amounts of oil were to reach the wetlands was emulsification.Â At the milligram level, surfactants are quite a useful trick, but at the tonnage level needed to disperse the oil that was not mixing with the gulf waters, even the oil industry's environmental engineers had their doubts.Â

Nobody is sure what's in store for the gulf coast, but we will certainly learn a lot about the chemistry of mixing oil and salt water.

The floodwaters are still receding in Nashville, but the clean-up is well underway.Â The stage of the Grand Ole Opry was underwater on Tuesday, May 4, but "the show must go on" is another saying, and it did, on higher ground.

Preston MacDougall is a chemistry professor at Middle Tennessee State University. His "Chemical Eye" commentaries are featured in the Arts and Public Affairs portion of the Murfreesboro/Nashville NPR station WMOT (www.wmot.org).

Click here to read a previous Chemical Eye On

Chemical Eye in Nostradamus Mode

After the Iron Lady catalyzes the oxidation of the Iron Curtain,
An angel will arise after a murky election in the land of Bayer.
The identity and material power of the central science is certain,
Therein will crystallize the first President from the sex more fair.

Call it providence, or perhaps the promise of "better living through chemistry", but the first female President of the United States of America will be a chemist.Â My apologies to Hillary and Sarah.

And, in case you couldn't decipher the Nostradamus-style quatrain, our future Madame President will follow in the high-heeled footsteps of the first democratically elected, female leaders of the United Kingdom and Germany--Dame Margaret Thatcher and Dr. Angela Merkel.

Dr. Merkel's ability to solve complex problems, such as those that she specialized in as a quantum chemist at the Academy of Sciences in East Berlin, no doubt helped her piece together a "grand coalition" government after Germany's "hung election" in 2005.Â Given the rarely-seen (at least in Europe) political squabbling following the election, that was a feat few thought possible.

Another event that few thought possible was the tearing-down of the Berlin Wall.Â Prior to November 9, 1989, this impermeable barrier separated Dr. Merkel from the Christian Democrats, the political party that she was destined to lead.Â The wall, and The Iron Curtain that it was part of, did not collapse under its own weight - not literally anyway.Â Margaret Thatcher had been Prime Minister of the United Kingdom for over ten years prior to this precipitous event, and she had earned the nickname of The Iron Lady.Â So, in this case, when the unstoppable force met the immoveable object, the object moved.Â (Sir Isaac Newton would have been gratified to see his First Law of Motion obeyed by world politics.)

Prior to her political career, and marriage to Mr. Thatcher, Margaret Roberts was a chemistry major at a second tier college.Â Her intellectual gifts earned her a transfer to Oxford University, where she was tutored in advanced chemistry and crystallography by Dorothy Crowfoot Hodgkin.Â While Professor Hodgkin would go on to win the 1964 Nobel Prize in Chemistry (for X-ray crystallographic analysis of the structures of molecules with biological importance, such as penicillin and vitamin B12), Ms. Roberts took a Masters degree in 1947 and entered politics.Â It would take over thirty years, but she eventually became leader of the Conservative Party, and then her country.Â And, some said, "the free world."Â Â

This predicted migration pattern of chemically-talented, first female leaders of major economies - United Kingdom, Germany, United States - oddly follows the migration of world dominance of the modern chemical industry.Â In 1856, with rudimentary facilities in his family's East London home, young William Perkins transformed primitive organic chemistry into the new, and immensely profitable, synthetic dye industry.

Industrial chemistry is the ultimate labor-saving social development.Â Its custom designed reagents and catalysts, both organic and inorganic, do the work of yeomen, without wages, and never go on strike.Â As such, the United Kingdom, land of the Luddites, wasn't the most hospitable environment. The center of mass action shifted to Germany just as the chemical industry was starting to branch out into pharmaceuticals.

Bayer launched the new blockbuster drug Aspirin in 1899.Â Synthetic dyes and drugs both begin their new molecular lives as the result of clashes between chemically forceful catalysts, and rock-stable, over geological periods, petrochemicals.Â Sir Isaac's First Law rules again.Â

The first World War, which cut off the supply of German chemicals to U.S. manufacturers, spurred the development of American chemical companies, such as Dow Chemical which initially supplied the drug industry with the bromine that it needed to make the bromides everybody needed to cope with a world that was at war.Â

The second World War had a similarly boosting effect, particularly in supply of the automobile industry that was getting into high-gear in the U.S.Â Cars need a steady supply of evermore refined fuel, and the chemists who had demonstrated that they were masters of the petrochemical domain, soon started a new, and hefty branch of the chemical industry.Â

As the Nazis embroiled Europe in World War II, in addition to supercharging American industries, American universities welcomed many of the world's most chemically talented refugees.Â Some have gone on to win a Nobel Prize, others started their own market-leading chemical company.Â All in all, the center of mass action shifted again, this time to the United States, where it rests uneasily.

There is nothing that can shield the U.S. chemical industry from Sir Isaac's First Law.Â What forces might emasculate it, as the labor movement did, to some extent, in the United Kingdom, or the Nazis did in Germany?Â The one that worries me is the diminishing scientific literacy of the American public.

So, Madame President, if in the future you have searched the internet archives, and are reading this commentary that called you into existence, please make scientific literacy of all Americans a priority for your administration, and a core responsibility for those who follow you.

Preston MacDougall is a chemistry professor at Middle Tennessee State University. His "Chemical Eye" commentaries are featured in the Arts and Public Affairs portion of the Murfreesboro/Nashville NPR station WMOT (www.wmot.org).

Click here to read a previous Chemical Eye On

Chemical Eye on Homeopathic Education

In homeopathic medicine, the more diluted a treatment is, the more powerful its effect is believed to be.Â This branch of medicine dates back to Germany in the late 1700s, before germ theory and DNA added a few twists to our understanding of disease.Â Nevertheless, this form of alternative medicine has a loyal following despite the skepticism of critics such as James Randi.Â With the increasing cost of drugs, it certainly has economic advantages.

Recent news from Middle Tennessee is suggestive of a new counter-intuitive movement that would bring incredible tax-relief if we all believed in it--homeopathic education.

As far as I know, nobody is openly promoting homeopathic education in the way that followers of Samuel Hahnemann have promoted homeopathic medicine for over 200 years.Â But when I read about some school board decisions, I often ask myself "What were they thinking?"

Pisa is a city in Italy that is famous as a center of Renaissance thinking.Â It is where Galileo was born, educated, and began shaping modern science with his sharp tools of critical thinking.Â PISA is also the acronym for the large-scale Program for International Student Assessment, which is given every three years to almost a half-million 15-year-olds from 30 industrialized countries.Â

The results of the most recent international assessment were echoed by this year's National Assessment of Educational Progress, often called the National Report Card.Â The results are even more disappointing than previous ones when you consider that the No Child Left Behind legislation signed into law in 2002 was meant to directly address the core competencies that are the focus of PISA.Â

As before, we learned that high school students in the U.S. score far below average in their mathematical competency, and slightly below average in their ability to apply scientific reasoning in problem-solving.Â For U.S. students, officials said that all the results of the reading portion of the test were discarded because of a printing error.

In a global economy, it is surely not a good prognosis when American teens were out-performed by their peers in 23 out of the 30 industrialized countries on the mathematics portion of the test.Â Math is often said to be the language of science and engineering, so perhaps not all of our "reading" results are invalid.

In response to the PISA results, then-U.S. Secretary of Education Margaret Spellings echoed the disappointment and cited ongoing initiatives to strengthen math and science education in American schools.Â In particular, a National Math Advisory Panel was appointed by President Bush in order to "recommend ways to improve public school math instruction, with a focus on algebra."Â President Obama has continued this initiative, and has repeatedly mentioned mathematics explicitly during his speeches on education.Â

So far, so good.Â But here's where my fears of homeopathic education started creeping in.Â Last fall, the Metropolitan Nashville school district decided to stop teaching algebra to 7th grade students who were ready for advanced mathematical education.Â As a point of reference, on my bookshelf there is a middle school textbook from Japan where the quantum theory of atomic structure is introduced--quantitatively.

If you are like me, you might be wondering what the school board planned to replace the advanced mathematics instruction with.Â In homeopathic medicine, the drugs are diluted with pure water.Â Perhaps a hint of the tenets of homeopathic education is contained in news from another Middle Tennessee school district that announced the formation of an elementary school competitive basketball league.Â

So even though international student assessments don't give us much to feel good about, at least half of the hometown crowd can cheer for the winners when Central Elementary plays Main Street Grammar.

Basketball or basket-weaving, I am inclined to root-out any and all efforts to dilute math and science education since this is the training that will give our students the sharpest competitive edge in the technology-driven global arena.Â

For tax-weary sports fans, former president of Harvard University, Derek Bok, looked at things from an economic perspective when he said "If you think education is expensive, try ignorance."

Getting back to the medical analogy, since all credible clinical studies have concluded that homeopathic medicine offers nothing but a placebo effect, it is only economical if you place a low value on your health.

Click here to read a previous Chemical Eye On

Chemical Eye on Raveling DNA

The normal fate of a pair of jeans is to be worn out.Â Never mind the different definitions of "worn out" on either side of the generation gap.Â

In between wearings, however, they must be stored, and again the generation gap inserts itself.Â Like I did at his age, my son prefers the crumpled pile method.Â Nowadays I opt for folded.Â I'll admit it; I did try hanging, but later discovered that Mommie Dearest was right--no metal hangers, ever!Â Vertical creases go in and out of style, but horizontal creases?Â Definitely a fashion faux pas.

There is undoubtedly some interesting chemistry behind why cotton is more susceptible to being creased than other fabrics, which may involve the specific protein molecules that are fabricated in the cells of cotton plants, but a bigger mystery is the long-sought secret code to packing long DNA molecules into compact chromosomes.Â Since our DNA also contains the codes for our numerous inherited genes, you could say that this new, embedded code may reveal nature's preferred method for folding genes.

During cell division, and when the gene codes are being read, or "transcribed", in order to synthesize proteins following natural just-in-time procedures, our chromosomes must quickly unfold and unravel into the stringy double-helix form that has become iconic.

After taking care of business, the 23 pairs of double-stranded DNA molecules, which would range a few meters in length if completely straightened out, and contain thousands of genes each, must just as quickly ravel and fold back into the familiar butterfly shapes that can be seen under the microscope.Â Properly folded, they all fit in a drawer (our cell nucleus) that only measures a few millionths of a meter in diameter.

Ever helpful, my mother sent me a link to the "How to fold a shirt " movie clip.Â I couldn't understand a word of the folder's explanation, but I was impressed by the simplicity of the method.Â Just one fold, a couple of shakes, and voilÃ - a perfectly folded shirt!Â We do a far more impressive folding job with our genes, but scientists aren't completely sure how we manage to do it.

We have known for decades now that metals are needed to begin the process.Â In particular, positively-charged metal ions both balance the electric charge on a DNA molecule in cell conditions, and act as a sort of template for coiling the double-helix in the first phase of gene folding.

Metal ions are much too small to assist in the next folding phase, which involves wrapping the thickened coil around tiny spools to form evenly-spaced beads called nucleosomes.Â You can think of a very long pearl necklace (unfastened) where the valuable part is not the pearl, but the string.Â Â And the string doesn't go through holes in the pearls, but is wrapped around neat stacks of eight pearls each - precisely 1.65 times, or 147 units of genetic code.Â

Each of our cells contains millions of such spool assemblies, which are themselves called histones.Â Despite their rocky name, and the analogy to pearls, histones are not mineral, but made of protein, and have been studied in atomic detail.

DNA doesn't just wrap around histones in a repetitive manner--the looseness of the fit also responds in a highly predictable way to changes in the chemical environment.Â Harvard chemist Stuart Schreiber is among those at the forefront of what has been called epigenetics .Â Such research is unraveling the changes in molecular structure, to either DNA or the histone surface, which cause DNA to unravel completely, or just enough to enable some essential biochemical process to occur.

One of the key chemical changes is acetylation.Â This is the same minor chemical modification that Bayer chemist Felix Hoffman made to willow bark extract over 100 years ago.Â Students routinely redo this experiment in freshman chemistry labs when they make Aspirin on their own.Â Various diseases, and embryo development failures, are thought to be caused by erroneous folding or unfolding of DNA.Â So this research is not just an elaborate Sudoku puzzle - done just for fun.

The atomic understanding of histone structures in various organisms, as well as accumulated knowledge of the effect of site-directed chemical modifications, has led to clues about what causes DNA to fold and unfold at the proper place and time.Â In particular, research by large teams of molecular biologists and biochemists, undoubtedly wearing out numerous hard-working grad students, has led to the supposition that our DNA has a so-called "histone code" embedded along with its genetic code.

Scientists figured that there was no other way to explain the regular, and chemically regulated, attachment of genetic material to histones.Â I suspect that a few Nobel Prizes will be won for key discoveries and technical prowess during the ongoing race to decipher the nuances of the histone code.Â One thing is sure though, unlike Dan Brown blockbusters, this unfolding story is non-fiction.

Preston MacDougall is a chemistry professor at Middle Tennessee State University. His "Chemical Eye" commentaries are featured in the Arts and Public Affairs portion of the Murfreesboro/Nashville NPR station WMOT (www.wmot.org).

Click here to read a previous Chemical Eye On

Chemical Eye on Superheroes vs. Superbugs

The purveyors of death and destruction freely continue their mountainous transit from Afghanistan into Pakistan, and there is nothing that more boots on the ground or drones in the air can do about it.

In fact many local leaders welcome these parasites, and protect them from multinational defenses.Â Â You would think that replacing fear of death, with life and liberty, would garner a hero's welcome.Â But no, some imams are preaching falsehoods, vilifying true heroes, and endangering the lives of countless innocents.

I am not referring to the ruinous spread of the Taliban, although their barbaric ways seem to get a free pass in this border region.Â It is news of harboring microbial pathogens that disturbs me.Â The U.N. has reported that the polio virus, a distant nightmare of the elderly in Western countries, is hacking its way into unprotected Pakistani children via infected Afghan refugees.

Thanks to heroic efforts of people like Jonas Salk, polio vaccination had all but eradicated this microscopic terror, from nearly all corners of the globe.Â Unfortunately, beginning in northern Nigeria in 2003, a new strain of the virus has now spread to at least 16 countries.Â It is predominantly Muslim-ruled countries or regions that are being hit the hardest.

It is not the religion that poses a health danger, but rather the mutating doctrine of some practitioners.Â For instance, Indonesia has long been a producer of polio vaccine for the region, and thought it had treated its last case of childhood polio in 1985.Â But that was before some Muslim leaders, for reasons that I cannot fathom, began spreading the big lie that the vaccine was created to spread AIDS among Moslems and sterilize Muslim girls.Â I haven't yet seen Dr. Salk burned in effigy, but it wouldn't surprise me.Â On a map, the virus seems to be following in the wake of the lies, and Indonesia was hit by a wave of new polio cases in 2005.

Fortunately, current vaccines are still an effective defense against the virus, and rapid coordinated action by the World Health Organization and the Indonesian government put an end to the resurgence.Â Now if only there were a vaccination for ignorance that was as easy to administer.

Another dangerous example of fool's logic is "the enemy of my enemy is my friend."Â For much, much longer than humans have been contracting syphilis or spreading tuberculosis (both bacterial infections), viral particles and bacterial cells have been engaging each other in mortal combat on microscopic battlefields.

But, since the polio virus attacks our cells that control muscle movement, and in advanced stages of AIDS, the HIV virus can attack many types of cells in our bodies, it would be a stretch to call these little nasties our friends.

In fact, a growing concern in the medical community are so-called superbugs--infectious bacteria that are resistant to the most potent antibiotics that medicinal chemists can cook up.Â Still, there are superheroes to be found in these endeavors too.

Rubberman foiled many ubervillains with his plastic limbs and torso.Â Whereas the lesser-known "Waxman" achieved hero status in the battle against superbugs not by wielding paraffin, but plain old dirt.Â He might also be known by the alias Streptoman, since Selman Waksman won the 1952 Nobel Prize for Physiology or Medicine in recognition of his discovery of a potent class of antibiotics that are found in common soil.

Dr. Waksman and his students isolated numerous antimicrobial agents produced by literally garden-variety microbes belonging to the actinomycete clan.Â Chief among them was streptomycin, the first effective drug for tuberculosis.Â As part of the American Chemical Society's program of establishing National Historical Chemical Landmarks , a plaque honoring this and other achievements was placed in Martin Hall on the Cook College Campus of Rutgers University, in

New Jersey.

It is interesting to note that when he accepted his prize, he began his Nobel Lecture (which is available at nobelprize.org/medicine) with the following proverbial passage from the Book of Sirach, or Liber Ecclesiasticus as it is known in Latin (Chapter 38, verse 4):

"The Lord hath created medicines out of the earth; and he that is wise will not abhor them."

For a whole host of reasons, from over-prescription to bacterial evolution, yesterday's wonder drugs are no match for today's superbugs.Â Hopefully though, a new army of heroes, with the molecular skills needed to cleanly win battles against microbial terror, are being nurtured and trained in well-equipped chemistry and biology laboratories, both here and abroad.Â I also hope that they take to heart the foremost lesson for superheroes: "With great power comes great responsibility."

Education is not just the vaccine for ignorance, it is the key to living healthy, wealthy, and wise.

Preston MacDougall is a chemistry professor at Middle Tennessee State University. His "Chemical Eye" commentaries are featured in the Arts and Public Affairs portion of the Murfreesboro/Nashville NPR station WMOT (www.wmot.org).

Click here to read a previous Chemical Eye On

Chemical Eye on the Rear-view Mirror: Lost in Translation

Â (Marburg, Germany, June 2007)

A man's Schloss is his castle.

Since castle is the English translation of the German word Schloss, there is no hidden meaning in this otherwise homey expression.Â

Reading signs, listening to radio, and constantly eavesdropping, help build my German vocabulary.Â For instance, Germany had just finished hosting the G8 meeting when I arrived in Frankfurt, and on the train to Marburg there were many Germans reading the newspapers and discussing its contents.Â From what I could gather, Dummkopf is the German word for President.

My travel purpose is to visit the computational chemistry lab of Professor Gernot Frenking.Â Currently, students and visitors in the lab hail from India, Norway, Brazil, Japan, South Africa, Spain, Germany of course, and a graduate student from the U.S as well.Â English is the default language of science, so wherever their travels take them, it is usually possible for chemists to communicate.

It wasn't always so.Â Even with language barriers that can make ordering lunch distasteful, conventions for atomic symbols and elements of molecular structure have long-enabled chemists to engage in pictorial discussions about their research.Â Some of these conventions are relatively recent, as in the case of the element niobium.

Niobium is immediately above tantalum in the heart of the metallic region of the periodic table.Â Both elements were discovered in mines that contained "new earth minerals": niobium in Connecticut and tantalum in Scandinavia.Â The names of the elements have their origins in the deep vein of Greek mythology, and are particularly rich in metaphorical meaning.

When niobium was discovered in 1801, it was named columbium since it was the first element discovered in America.Â One year later, tantalum was discovered by a chemistry professor at Uppsala, Sweden, which was, and still is, a renowned center of chemical research.Â It was there that J. J. Berzelius developed the modern chemical notation to replace variously styled symbols originating with alchemists.Â Tantalum was denoted as Ta, and since Co was given to the more senior element cobalt, columbium was denoted as Cb - for a while.Â

Tantalum and columbium are very similar chemically, which we now associate with being in the same column of the periodic table.Â In 1809, a British chemist analyzed the minerals containing columbium and tantalum, and concluded that they contained the same element, tantalum.Â So, what we now call niobium, but was initially called columbium, was then referred to as tantalum.Â Confused?Â Now you know how I feel riding the buses in Marburg, amongst young, chatty German students.

Since chemists hadn't yet developed a reliable method for determining atomic weights, this state of confusion persisted until a German chemist, Heinrich Rose, discovered that portions of the tantalum from minerals discovered in America could form compounds that the tantalum from Scandinavian minerals could not.Â According to the new chemical philosophy, this could mean only one thing--they were different elements.Â This time, European chemists named it niobium, and gave it the atomic symbol Nb.

On the other hand, most American chemists resumed calling the element columbium and using the symbol Cb--for over 100 years!Â The International Union of Pure and Applied Chemistry settled the matter in 1949, and since then periodic tables around the world have Nb at position number 41.Â

This often still causes confusion for students, such as it did for me many years ago when I was reading an article in an old volume of the Journal of the American Chemical Society.Â It contained chemical reactions that interested me, but what was this Cb?Â I remember thinking it must be a typo.Â When I asked my professor a question about this chemistry, I got a lesson in modern history.

Â
A peach tree in bloom.
If it fails to yield fruit, are you impeached?
Credit: morguefile.com
It is history from the Classical Age that explains the modern names.Â Tantalum was named after Tantalus, a demigod in Greek mythology.Â And since niobium was not properly identified until it could be chemically separated from tantalum, it was named after Niobe, an unfortunate daughter of Tantalus.

Tantalus also had a son, who he gruesomely sacrificed in order to appease the gods after offending them by giving away secret knowledge to the masses.Â He was punished by having to spend eternity standing in a pool of fresh water, that receded whenever he bent to drink from it.Â He also stood below a fruit tree (sources tell me it was a peach tree), that would lift its branches whenever he reached for fruit.Â Thus the gods made sure Tantalus was "impeached".

Tantalus's predicament gave us the English word tantalizing, and it came to mind when its discoverers observed the unusually inert chemical behavior of tantalum.Â While all other metals react vigorously with strong acids--even gold, if the acid is strong enough--tantalum appears unable to.Â It can, but only if its Resistant Oxide Veneer, or ROV, is removed from the surface.

Anonymous sources, with reliable connections to Classical scholars, add that Tantalus repeats the same answer whenever his people ask how things are going.Â He says "," which is a mispronounced ancient Greek version of "I'm workin' hard, and makin' progress."

Preston MacDougall is a chemistry professor at Middle Tennessee State University. His "Chemical Eye" commentaries are featured in the Arts and Public Affairs portion of the Murfreesboro/Nashville NPR station WMOT (www.wmot.org).

Click here to read a previous Chemical Eye On

Chemical Eye on Carbonated Air: From "Oh, Oh!" to "O-la-lah!"

What goes up, must come down.Â Or so we thought until the power of scientific thinking both explained the force of gravity and produced equal (or greater) and opposite forces that could be sustained long enough to overcome it.

We've not just been inspired by the heavens, but been headed that way ever since.Â

Eventually we won't have any choice.Â Astrophysicists have used the same laws of gravity, in conjunction with our new Promethean knowledge of the nuclear processes that make the stars shine, to predict that when our Sun starts to run out of hydrogen it will turn into a red giant--hundreds of times its current size.

It's difficult to predict the fate of the Earth , but none of the likely scenarios are rosy.Â They range from being consumed by the Sun's plasma, to being flung into the outer solar system - after being incinerated.Â The good news is that the Sun has enough hydrogen to keep humming along for several billion years.Â That gives us plenty of time to solve the crisis of faltering science and math education in many of our public school systems, and a few private ones as well, where using the b-word in the Earth's age could result in a red giant welt on your b-hind.

Or does it.Â There is also plenty of scientific uncertainty in the much more immediate temperature forecast for planet Earth.Â I'm not talking about whether or not I'll be able to take my Tommy Bahama outfits out of storage next week, but whether or not all the Bahamas will still be above water in a hundred years.

It won't improve the certainty of the models, but it just might reduce some of the confusion, if the public understands that global warming and the causes of it are two logically separable problems.Â The first is largely an experimental challenge, and the second is primarily a theoretical one.Â All theories, leading or fringe, of what might cause global warming need to be tested with computational and experimental models, but even those are logically separable problems.Â Science works best when big problems are broken down into small problems, and groups work on them independently--without political pressure.

Even under the best conditions, science has its ups and downs.Â But it always seems to move forward.

For the sake of less argument, let's assume that the in vogue theory is correct; that the increasing levels of atmospheric CO2, due to the accelerating combustion of fossil fuels since the dawn of the industrial age, results in a "greenhouse effect" that is causing global warming.Â This geochemical theory , postulated with atomic detail by Swedish chemist Svante Arrhenius , has survived over 100 years of dismissive skeptics and over-zealous supporters, so it deserves some respect.

We still have the experimental problems of accurately measuring global temperatures, as well as concentrations of CO2, both in the atmosphere and dissolved in the oceans.Â None of these are cheap, or easy.Â Cost overruns in NASA's ambitious, but scientifically essential plans to replace the aging fleet of Earth-observing satellites are threatening its political support.Â And just last month, the satellite that was intended to provide decades of high-resolution mapping of CO2 concentrations around the planet unexpectedly fell into the Pacific Ocean, where it was not equipped to measure concentrations of dissolved CO2 or related carbonate ions, even if it survived the splash intact.Â

This was a painful, and expensive reminder that the "what goes up, must come down" theory still applies to satellite launches when it is in conjunction with the "accidents do happen" theory.Â It seems that the rocket launch was perfect, and the satellite would have reached orbit if the explosive bolts securing the heavy metallic shield had detonated on cue.Â They did not, "oh, oh" was heard in the control room, there was a less-than-equal and opposite sustained force opposing gravity, kerplunck.

Â
Â credit: morguefile.com
If satellites are not your thing, and you don't mind working with superacids, there are experimental projects underway in organic chemistry labs that seek to recycle excess CO2 in the atmosphere by recombining it with water and the copious amounts of energy that surround us in the form of light and heat, to synthesize methanol and other valuable fuels - out of thinly carbonated air!

This ambitious research is being pioneered by George Olah's group , in the Loker Hydrocarbon Research Institute at the University of Southern California.Â Like Svante Arrhenius, George Olah is a recipient of the Nobel Prize in Chemistry--in Olah's case for pushing the envelope of carbon chemistry - so even though his ideas may sound too good to be true, they deserve some respect.

You'd be surprised what can be achieved when the laws of chemistry and thermodynamics operate in conjunction with the "necessity is the mother of invention" theory.

Preston MacDougall is a chemistry professor at Middle Tennessee State University. His "Chemical Eye" commentaries are featured in the Arts and Public Affairs portion of the Murfreesboro/Nashville NPR station WMOT (www.wmot.org).

Click here to read a previous Chemical Eye On

Chemical Eye on "Cap and Trade"

On the economic frontline of the carbon wars, a lot of political hot air has been expended over the cap-and-trade strategy for reducing greenhouse gas emissions.Â But is it all just smoke and mirrors?

For instance, in 2008 the Canadian provinces of Ontario and Quebec signed a formal agreement that puts a new cap on greenhouse gas emissions, but allows green industries to trade their unused quotas with industries that are still a bit brownish.

I hope this strategy encourages creative research into alternative energy sources and chemical processes that reduce waste products, but if it is anything like the Kyoto Protocol it should set off smoke alarms.

Why?Â You may recall that when the US refused to sign the Kyoto Protocol, we were subjected to blasts of hot air from our neighbors to the North who did sign it.Â So what has happened in the meantime?Â Of the industrialized countries that have not come close to meeting their Kyoto targets, Canada tops the list.Â In fact the Canadian government admitted that since Kyoto went into effect, per capita emissions of the monitored gases have gone up in Canada, and by more than they did in the US!

Maybe politicians can't make any sense of data unless it comes from a pollster, or maybe they just forgot to put batteries in their smoke alarms.

In any case, the failure of the Kyoto Protocol isn't the reason for my skepticism about the cap-and-trade strategy.Â It is the failure of the War on Drugs.

If that sounds like a non sequitur to you, you must not listen to much rap music.Â You see, after decades of draconian drug laws, cap-and-trade has been the recipe for "success"-- but for the wrong side.

credit: morguefile.com
In today's urban slang, to "cap" someone is to shoot them with a handgun.Â It is troubling enough that such immoral language has rooted itself in popular culture, but the most disturbing fact is that this violent crime is increasingly a horrific reality.

Whether it be in the poppy fields of Afghanistan, or on the streets of Matamoros, Mexico, or even in rural Tipton County, Tennessee, when a drug dealer is confronted with enforcement of drug laws their strategy is the same: cap the authority and continue to trade.

Both the US military and the Afghan government have identified the same primary threat to democracy in Afghanistan.Â It is not al Qaeda, nor is it the Taliban.Â It is the illegal opium trade.Â You do not have to minimize the evils of drug abuse to question the war on drugs.Â You only have to argue that the horrific consequences of the drug laws might actually be worse.

Kandahar may be half a world away, but Americans who live near the Mexican border know that chaotic violence is at our doorstep.Â Entire towns in Northern Mexico have erupted in drug-related violence.Â In some places, the drug dealers are killing off the local police, while in others the federal agents are battling with thoroughly corrupted police.Â

When the war on drugs has hardened frontlines that pierce the institutions that are charged with enforcing laws, perhaps it is time to examine the laws themselves.

I am advocating re-examination of our drug laws for two general reasons.Â First, I value all personal freedoms, even though I would not choose to use drugs that are currently illegal.Â Secondly, I have faith in education.Â If students can be taught the quantum mechanical mechanisms by which CO_2 absorbs and emits radiation , then they can be taught not to abuse drugs.

I also have a specific reason for advocating controlled drug markets, as opposed to illegal ones.Â His name was Calvin Jenks.Â I never met this Tennessee State Trooper, but before he married his high school sweetheart, I taught her Honors Chemistry and served on the committee that evaluated her honors thesis research in microbiology.Â She was most deserving of the slot she was awarded at the University of Tennessee College of Medicine.Â It broke my heart to learn that her husband, while making a routine traffic stop in rural Tennessee, was killed by drug dealers who were on their way to make a trade in Nashville.

In the carbon wars, whether our target is carbon dioxide or psycho-active carbon-containing compounds, instead of demonizing inanimate molecules, let's tax them.

Coincidentally, shortly after visiting the Canadian capital, President Obama's first budget proposes taxes on greenhouse gas emissions.Â I hope that other policy changes await the return from his first visit to Mexico City.

Preston MacDougall is a chemistry professor at Middle Tennessee State University. His "Chemical Eye" commentaries are featured in the Arts and Public Affairs portion of the Murfreesboro/Nashville NPR station WMOT (www.wmot.org).

Click here to read a previous Chemical Eye On

Chemical Eye on the Units of Heroism

After two planes crashed in New York City on September 11th, 2001, there seemed to be confusion everywhere, and about everything.Â There was even confusion about who the heroes were.Â In the peace-loving parts of the world, the first-responders were the heroes.Â In the caves and shadows hiding Islamic extremists, the pilots were.

I was too confused to cry.Â As my syllabus had scheduled, I lectured about Newton's universal law of gravitation.

When a plane crashed into the Hudson River last month, and all 155 people on board safely made it to shore, I wept sweet tears of joy and admiration of technical perfection.Â There could not be a shred of doubt as to the identity of the hero, the only question was how big?

Unfortunately, we have a more recent and tragic reminder of how gravity can be very unforgiving of even small errors, which we all make.Â The crash of the commuter plane near Buffalo helps us better appreciate the heroism above the Hudson by Captain Chesley Sullenberger, or "Sully", but how do we measure it?

Lord Kelvin - a hero to thermodynamicists everywhere - was a famous proponent of measurement.Â Among his quotable thoughts on the matter: "To measure is to know" and "In physical science the first essential step in the direction of learning any subject is to find principles of numerical reckoning and practicable methods for measuring some quality connected with it."

It is easy to get carried away with the act of measurement - as we have witnessed in our public schools--when we forget the crucial part of Kelvin's message.Â That is, in order to "know" about one thing, by measuring another, there has to be a connection that is based on sound principles.

I don't know any "practicable methods" for measuring heroism, but I do know that the most important part of any measurement is not the number, but the unit of measurement.Â Accordingly, the discussion of units is prominent, and scheduled early in the syllabus of any course that I teach.

A lot of students, who have been bored to tears with metric drills in high school, don't think this is science at all.Â They want "stinks and bangs".Â Those will come later, along with shape-shifting polymers and other cool chemistry, but first they need to understand the importance of units.Â I quote Kelvin, and tell them the story about the Gimli Glider .
Â
 credit: morguefile.com

None of my students have ever heard the story before, and many don't believe me when I'm done - especially the aerospace majors.Â If you have heard the story before, you already know the ending but pay attention to the units, that's the important part.Â

On July 23, 1983, a relatively new Boeing 767 was getting ready to fly halfway across Canada--from Montreal to Edmonton.Â It needed a full tank of fuel to get there.Â The problem was that the fuel gauges in the cockpit were blank.Â There was a known glitch in the gauges, and it was standard procedure to approve take-off when they were not working, if the fuel level was measured manually and the pilot calculated that there was sufficient fuel on board.Â

The full flight required 22,300 kg of fuel, and the manual measurement of the fuel level on board indicated there was 7,682 liters in the tanks.Â Kilograms and liters are both metric units, but one is a unit of measuring mass, and the other is a unit of measuring volume.Â You can't convert apples to oranges, but you can convert liters to kilograms.Â You just need to know the density of the fuel.Â As you learned on one of the less exciting days of science class, density is mass over volume.Â And as your algebra teacher explained, that means that mass is volume times density.

If you're getting bored, hang in there, it's about to get really interesting.

The ground crew multiplied the volume on board by the density of fuel in pounds per liter to get the mass of fuel on board, which they then subtracted from the needed fuel to determine how much they needed to put in the tanks.Â If you're still wondering what was with the apples and oranges, it is this: One pound of apples weighs less than half as much as a kilogram of oranges.Â Canada had just converted to the metric system, so there was confusion everywhere about everything.

Captain Robert "Bob" Pearson checked the calculations of the ground crew, and approved the arithmetic.Â But since there were no units shown in the equations, he did not notice that the numbers were bogus.Â The plane took off, with 61 passengers.Â A little over half-way there, the plane ran completely out of gas at an altitude of 41,000 feet.Â Actually, since they were over Northern Ontario, heading into Manitoba airspace, the altitude was 12,500 meters.Â Feet or meters, the force of gravity that began to exceed the lift force on the wings was the same.Â Down.

Bob Pearson was an amateur glider in his spare time, and amazingly landed the plane on a decommissioned runway, that had been converted into a dragstrip in the small farming community of Gimli, Manitoba.Â Nobody was seriously injured, and the plane continued in service for several years, known afterwards as the Gimli Glider.Â Captain Pearson was temporarily demoted, but also awarded a medal for Outstanding Airmanship.

In addition to conveying the importance of units, this story illustrates that measuring heroism is not an easy task.Â The important thing is to honor it.

Preston MacDougall is a chemistry professor at Middle Tennessee State University. His "Chemical Eye" commentaries are featured in the Arts and Public Affairs portion of the Murfreesboro/Nashville NPR station WMOT (www.wmot.org).

Click here to read a previous Chemical Eye On

Chemical Eye on Staging a Stimulus

I'll probably get labeled a "ham radio commentator", but I want to return to the play metaphor that I used to interpret

Barack Obama's Inaugural Address. That's because there's some serious "pork" in the economic recovery that he is trying to stage--and in certain cases I'm all for it.
I'll have grounds
More relative than this--the play's the thing
Wherein I'll catch the conscience of the King.
While Hamlet was trying to catch a villainous uncle, my theatrics are intended to help catch a $115 million science building that is desperately needed by the students and faculty here at Middle Tennessee State University. MTSU will celebrate its centennial anniversary in 2011, and that would normally not leave enough time to design and build a 131,000 net-square-feet building that houses technology-enabled classrooms as well as modern teaching and research laboratories for biology and chemistry. But, as the stage was being set for the economic stimulus package, guess what? The building had already been completely designed! It has even been given final approval by the Fire Marshal for the State of Tennessee. It truly is "shovel ready". Construction would have begun this year if the curtains hadn't started to fall on the economy. Even prior to that, however, there were backstage rumors of leading actors trying to get the building removed from the state budget script.Â But proponents of science at Middle Tennessee refuse to say "Uncle".
Wiser-Patten Science Hall, outside and in. Chemistry labs are intellectually stimulating, no matter what the dÃ©cor, but students need to be attracted inside to discover that. Credit: P. J. MacDougall

This is where the stimulus plan enters the stage. With great thanks to MTSU alumnus and congressman Bart Gordon , Chair of the House Committee on Science and Technology, the new MTSU science building was written into the House version of the stimulus plan script. Alas, it didn't survive the earmark editing by the Senate, nor is it in the compromise plan that is likely to be signed into law by President Obama.

But there is a large amount of money allocated for the states to spend on construction and renovation of educational facilities, so there is still hope that a stack of blueprints will become gleaming reality on the MTSU campus as the stimulus plan plays itself out.

As the editing done by the Senate indicates, this hope is not universal. It isn't even state-wide. Some see this earmark as "pork", and are glad to see it written out of the stimulus script. I beg to differ, and would like to see the following prologue entered into the script.

The year is 1931, and the nation, including Tennessee, is in the depths of the Great Depression. But, with an eye on an ever more scientific future, the State of Tennessee appropriates $225,000 for the "erection and construction of a modern science building". That building is now called Wiser-Patten Science Hall, and it is still where we teach all of our freshman chemistry labs. The first impression of a chemistry and biology double-major, who has gone on to become a locally-based and internationally successful biotechnology entrepreneur , but was a freshman in 1966, was "Gee, what an old building!"

If it was "long in tooth" in 1966, how do you imagine young and bright Tennesseans react to their first chemistry lab in 2009? The building may be Roman neoclassical on the outside, but it is definitely Greek tragedy on the inside. And there used to be a hint of "Gone With The Wind".

Until the late â€˜60s, when the one and only renovation was done, Science Hall also housed the Department of Home Economics on the second floor. The dÃ©cor in this part of the building still has hints of the formal dining space where proper etiquette was taught to young Southern ladies. I like to imagine the Department Head raising her nose curiously, and with a gorgeous Southern drawl interrupting her lesson with "I do declare, what is that dreadful odor coming up the stairwell from the chemistry labs? It smells like the Yankees are coming--again!"

Let us return to the presently impending action of the stimulus plan. We need to consider not just whether the spending will create jobs today, but whether it will still be creating jobs decades from now.

Building new roads and bridges will create jobs today, but it gets us nowhere. Sure, according to your GPS they take us from A to B, but according to my EPS (Economic Positioning System) they'll eventually take us back to exactly the same consumer-driven, deficit-towing economy that had an engine breakdown last year.Â Honk if you give a damn. Frankly, my dear readers, I do.

Shovel-ready projects that will educate science students, and engage them in advanced research, will provide construction jobs today, and dream jobs in the future.

Preston MacDougall is a chemistry professor at Middle Tennessee State University. His "Chemical Eye" commentaries are featured in the Arts and Public Affairs portion of the Murfreesboro/Nashville NPR station WMOT (www.wmot.org).

Click here to read a previous Chemical Eye On

Chemical Eye on Saving Jazz

Jazzy students from Middle Tennessee State University.
Pictured: The Great Barrier Reefs and Tony http://www.thegreatbarrierreefsandtony.com/
Credit: P. J. MacDougall
I went to last night's student-organized "Save the Jazz" benefit concert in support of keeping WMOT on the air.Â We had a whale of a time.Â To further support this conservation effort, I would like to take five from my usual chemical world travelogue and contemplate a time of gifts.

"A Time of Gifts" is also the name of the first installment of the artfully told adventure of an English teenager named Patrick Leigh Fermor.Â In 1933, after being dismissed from a boarding school in Canterbury--for being caught holding hands with the local grocer's daughter--this high-spirited son of a distinguished British geologist decided to complete his education via "Independent Study". Â

You could say that he took the matter into his own feet, since he made extensive plans to walk across Europe--"from the Hook of Holland to Constantinople".Â The fact that the great Byzantine capital has been called Istanbul since 1453 is a hint to the reader that you are not about to begin a conventional travel guide.

In addition to his frequent, and characteristic, departures from his pre-set geographic curriculum, such as his climb into the castled Carpathian Uplands, Fermor takes us back and forth through European military, linguistic and social history at the sight of Roman fortification ruins, mutations of place spellings, and bits of unusual hand-made traditional clothing that had never seen a price tag.

The Nazis were gaining political strength as Fermor trekked through Bavaria. And he would later distinguish himself in the British military fighting against them during World War II.Â Â But I had never heard of him until I read an absolutely spellbinding personal interview in the May 22, 2006, issue of The New Yorker .

Fathers Day came soon afterward, and "A Time of Gifts" was a well-timed gift from my son Byron, the classicist.Â It swept me along in time and from a few familiar to mostly unfamiliar places, and when I got to the "TO BE CONTINUED" on the last page, it could mean only one thing: a trip to the bookstore for the second installment of Fermor's saga.Â This time it was a gift to myself.

"Between the Woods and the Water" begins at a bridge over the Danube that will take him into Hungary from Slovakia (so-named then and now, but Czechoslovakia when he actually wrote the book in 1977).Â It ends, when he descends down the valley of the Cerna River into Orsova, where it pours into the Danube just beyond its Iron Gate .Â From there he will follow the Blue Danube into the Black Sea.Â But before he tells us of his final approach to Istanbul, we must wait at the gate of TO BE CONTINUED.

The third installment is yet to be published, as far as I know, but I suspect (at least I hope) that it has been written.Â Fermor turned 19 between the woods and the water, and if his excellent health holds up, he will turn 100 in 2015.

A slightly younger adventurer, who also found inspiration from a trip to Istanbul, was at the center of another gift that I was most fortunate to receive.Â My wife and I bought each other tickets to a special concert in the historic Ryman Auditorium: the Dave Brubeck Quarter in collaboration with the Nashville Symphony Orchestra.

This was in 2004, and Brubeck was almost 84 at the time.Â When he played "Three to Get Ready" and "Blue Rondo Ã la Turk", I could tell that many in the audience were swept back in time to 1959 when he released his pioneering "Take Five" album.Â I wouldn't enter the world until over a year later, but my father wore out his vinyl copy of that recording, so perhaps I was a twinkle.

In any case, Brubeck was absolutely sparkling in Nashville, and didn't need his piano seat when the tempo required an upright attitude.Â At the end of the concert, and after a much appreciated encore, when the audience had been applauding for at least ten minutes, with our own upright attitude, Brubeck left the stage gracefully.Â He said he would love to play longer, but he had to leave to catch a flight to Germany--that night--for a concert tour in Europe!

In the "Take Five" liner notes, I learned that the fascinating blend of rhythms in "Blue Rondo Ã¡ la Turk" came from a synthesis of a rondo from his (Western) classical training, with African-inspired blues that swept up young musicians in the 50s.Â These two musical forms were bonded by a Turkish 9/8 pattern that caught his ear on the streets of Istanbul during a tour of gigs in the Middle East and India 50 years ago.

After the intermission, in the second installment, the quartet teamed up with the symphony to play some of Brubeck's new "classical jazz" compositions.Â They closed with "Take Five", and just like with Fermor's books, the story is not over but TO BE CONTINUED.

If you would like to save the jazz music at 89.5 MHz on the radio dial in Middle Tennessee, but also at WMOT.org in cyberspace, then make this a time of gifts, including vocal support, to our jazz-format NPR station.Â After all, the most important thing about great literature, great music, and great radio stations that do double-time as experiential learning opportunities for college students, is that they are...

TO BE CONTINUED.

Preston MacDougall is a chemistry professor at Middle Tennessee State University. His "Chemical Eye" commentaries are featured in the Arts and Public Affairs portion of the Murfreesboro/Nashville NPR station WMOT (www.wmot.org).

Click here to read a previous Chemical Eye On

Chemical Eye on Transitioning from Pluribus to Unum

I was in a play last week, and it was a surreal experience.Â I played the part of a philosophical chemistry professor in a modern, scarcely recognizable remaking of "As You Like It" by William Shakespeare.Â What part did you play, or didn't you realize that you were in it too?
All the world's a stage,
And all the men and women merely players;
They have their exits and their entrances,
And one man in his time plays many parts
His acts being seven ages.
And players flub their lines occasionally, as did President Barack Obama and Chief Justice John Roberts, just before the much-anticipated Inaugural Address of the 44th President of the United States of America.Â It wasn't to be, or not to be, a soliloquy, since on the one hand, Barack Obama was onstage speaking to the entire world, not just to himself.Â But on the other hand, the inspiring theme of the preceding festivities was "We Are One".

During the speech, when I still thought I was in the audience, I was set in our Honors College dormitory, surrounded by staff and students, including a foreign-exchange student from Iceland.Â The Dean was also there, as was a journalist who covers the education beat for the local paper.Â As I listened, I started to realize that the words were not just words, but each one seemed to have a physical impact on me.Â This was momentous.

Afterwards, the reporter took a few students aside to get some reactions for his review, the Dean whispered his personal review to me--"I thought it was weak"--and there seemed to be a never-ending succession of talking heads complaining that "there wasn't anything that would make it into Bartlett's ".Â I was flabbergasted.Â I could only think "Don't these critics get it?Â We're not in the audience anymore!"

This eerie feeling started to set in when Obama said these audaciously hopeful words:
"We cannot help but believe that the old hatreds shall someday pass; that the lines of tribe shall soon dissolve; that as the world grows smaller, our common humanity shall reveal itself; and that America must play its role in ushering in a new era of peace."

The lines of tribe shall soon dissolve!Â I still get goose bumps thinking about that hopeful prophecy.Â But is it just wishful thinking?Â As usual, for me anyway, an analogous physico-chemical phenomenon immediately bubbled-up in my imagination: the superfluid transition of liquid helium.

When a liquid freezes into a solid, for instance, this is called a "phase transition ".Â And you would be amazed at how many renditions there are of this seemingly simple act.Â A liquid can also boil, of course, but did you know that pure solids can rapidly change size and/or shape right on (temperature) cue?Â When heated above its transition temperature, a crooked wire of nickel-titanium alloy will become straight as a pin.Â And when pure plutonium is heated, it will adopt four different crystalline forms, expanding by a whopping 25%, before it gets downsized to yet another two crystal structures, and finally shrinks when it melts at 640 degrees Celsius. These are the seven acts of plutonium before it vaporizes.

Respectively, these phase transitions create exciting opportunities for new medical devices, and intimidating technical challenges for maintaining the safety of our nuclear weapons stockpile.Â But they contain no hint for the social transition that must occur when lines of tribe dissolve.Â For that, you need to witness the superfluid transition of liquid helium. Â

Aside from its incredibly low temperature of 270 degrees Celcius--below zero!--helium boils, evaporates, swishes and swirls like any other liquid.Â But if it cools one degree further, it undergoes a sudden transition to a superfluid that is unlike any other form of matter.Â It completely lacks viscosity, and behaves in a way that defies logic as well as gravity.Â What is happening at the atomic level, and cannot be completely explained by theoretical physics, is that the trillions and trillions of helium atoms are no longer behaving as a collection of independent atoms, constrained only by the surface of the liquid, but as a perfectly coherent, frictionless whole.Â E pluribus unum.

This play isn't over, and each of us needs to be ready to transition to our next role, whatever that may be.

Cast members playing the audience in Lyon Hall during the Inauguration scene of "As You Like It", on January 20, 2009.Â
Credit: Amy Korstange

Preston MacDougall is a chemistry professor at Middle Tennessee State University. His "Chemical Eye" commentaries are featured in the Arts and Public Affairs portion of the Murfreesboro/Nashville NPR station WMOT (www.wmot.org).

Click here to read a previous Chemical Eye On

Chemical Eye On the Rising

Click to play: {audio}media/sound/UR.mp3{/audio}

On November 4, 2008, welling up in Chicago's Grant Park, news that Barack Obama was elected to be the 44th President of the United States of America spread across the world like a tsunami of emotion â€“ seeming to leave few unaffected.Â

In notches of both the Rust and Bible Belts there were responses that echoed a troubled past.Â But elsewhere in the country, as well as abroad--from symphony goers at Roy Thomson Hall in Toronto, to online bloggers down under in Sydney--the most resounding response was that of redemption.

He has indeed brought profound change to the highest office in the land.Â But, ironically, Barack Obama must now rely on the trickle down theory in order for his presidency to be successful.Â

Congress must change the way it operates.Â Federal departments must change the way they enforce national policies.Â States must be free to change in their own ways.Â Locally, we must change the way we educate our future workforce, especially in the areas of math and science.Â If we do all of this, and more, then perhaps we will indeed be "the change that we have been waiting for."

Change happens.Â This is basically guaranteed by the Second Law of Thermodynamics--a topic that is mentioned in many science, engineering, and even philosophy classes, and can even be spotted on the pages of some coffee table books with intimidating titles like "A Brief History of Time".Â Most students will have their most in depth encounter with this topic in a course called Physical Chemistry --or p-chem to make it sound more friendly.Â That is, unless they can find a way to avoid it.

In addition to learning the how, and much of the why, of change at the molecular level, not to mention neat experimental techniques that chemists use to probe molecular structures, they may get to put a coveted bumper sticker on their car â€“ Honk if you passed p-chem!

But the real joy of mastering p-chem is the sense of optimism that should accompany an understanding of the Second Law of Thermodynamics.Â Yes, change is inevitable, and for the entire universe it tends towards disorder.Â But, for carefully designed systems, which interact with their environment in smart ways, we can achieve the change that we desire.

Consider an ice cube.Â In the freezer, it is in the lowest energy state for water--a solid.Â (There are actually numerous solid structures of water, and probably more to be found, but the joys of p-chem are best appreciated incrementally, so we'll continue.)

If you move the ice cube to an ambient environment, such as a coffee table, it will do something remarkable â€“ it will melt!Â If this doesn't seem remarkable to you, consider how much you paid to fill-up your gas tank, then consider that the ice cube is taking the same kind of energy--enthalpy --and half-filling its molecular tank for free!Â (In steam engines these "tanks" are more completely filled, and not for free.Â Again, that's another quantum of p-chem joy that we'll save for another day.)

Plant cells do a similar thing, with much sweeter results, when they harness both solar energy and heat from the environment, in addition to carbon dioxide and water molecules, to make sugars and starches from scratch.Â Sugars are high-energy molecules, and can release their stored energy either in a controlled chemical digestion process, or in a catastrophic explosion.Â The Second Law is never violated, so change will happen.Â Murphy's Law, however, is not backed-up by science, and neither is it found in the indices of p-chem textbooks.Â We can avoid catastrophic change by enacting smart policies.

One set of smart policies was developed in 2005 by a committee of esteemed members of our National Academies of Engineering and the Sciences, and the Institute of Medicine.Â Their report was titled "Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future ".

If, as a country, we don't rise above the gathering storm, John McCain will have been prophetic in a metaphorical sense different from what he intended.Â We will all be Joe the Plumbers--trying to cope with a coast-to-coast flood of red ink.

Click here to read a previous Chemical Eye On

A Chemical Eye on a Cold Snap

Temperatures on the Fahrenheit and Celsius scales are defined relative to fixed points.Â For instance, on the Celsius scale, proposed in 1742 by a Swede named Anders Celsius, the freezing and boiling points of pure water, under normal atmospheric pressure, define O. and 100. degrees, respectively.Â All other temperatures are relative to these. Â

Water figures prominently in the definition of the Fahrenheit scale as well, but not pure water.Â If you've ever made ice cream the old-fashioned way--churning a mixture of rock salt and crushed ice that surrounds a can of fresh cream, sugar and other goodies - you know that the saltwater slurry gets darn cold.Â The ice cream mixture will slowly harden, or "freeze", but the salt and ice appear to melt into one another.Â Using the same thermodynamic principle, highways can be kept ice-free in the winter, but only to a point. Â

The point was discovered in 1724 by Daniel Fahrenheit, a German physicist, who wondered what concentration of saltwater would yield the lowest possible freezing point.Â It takes a lot of salt to reach the optimum mixture, but once you're there, you're as low as you can go.Â Any more, or any less salt, and the mixture will freeze at a temperature that is above zero on the Fahrenheit scale. Â

As folks in International Falls know, you can go lower.Â A century after Fahrenheit and Celsius weighed-in with their scales, a Scot named William Thomson became very interested in temperature's role in the practical applications of thermodynamics.Â In 1864, from carefully measured properties of relatively warm gases, he predicted that temperature on the Celsius scale could never go below 273.7 degrees below zero, ever.Â He called this temperature "absolute zero", and the temperature scale that begins and ends there is named after his subsequently acquired title of Baron Kelvin of Largs. Â

Under normal atmospheric pressure, air starts to liquefy at 190 degrees below zero on the Celsius scale.Â So there were some major experimental challenges to surpass before scientists would know whether Lord Kelvin was right. Air is mostly made up of the gases nitrogen and oxygen, in about a 4 to 1 ratio.Â Liquid nitrogen boils at 77 degrees on the Kelvin scale (which is a really cool 320 degrees below zero on the Fahrenheit scale), and is often used by dermatologists to remove pre-cancerous skin lesions. Â

A few years ago, during National Chemistry Week, which is held each fall, students in the MTSU Chemistry Club delighted local elementary school students with another use of liquid nitrogen--making ice cream !Â (I guess the tediousness of churning salt and ice for thirty minutes or more just doesn't appeal to youngsters today.)Â Using the same ingredients of cream, sugar and goodies, but just mixing in a couple liters of liquid nitrogen, the frozen treat was ready to eat in a few minutes.Â No salt, no ice, no bucket or crank (unless you count the seasoned chemistry professor who misses the thermodynamic beauty of the old-fashioned method).

There are other gases with even lower boiling points, and in the game of boiling point limbo, helium wins.Â The liquefaction of helium was a major breakthrough in experimental physics, ushering in the new field of "low-temperature physics ", where all sorts of weird and wonderful phenomena occur, such as superconductivity.

The freezing Dutchman, H. Kamerlingh Onnes, achieved this feat in 1908, when he observed liquid helium for the first time at the near-bottom temperature of 452 degrees below zero Fahrenheit, or a measly 4.2 degrees on the Kelvin scale.Â Since the planet Jupiter is composed primarily of the elements hydrogen and helium, you could say that he observed "drops of Jupiter" long before Train recorded their chart-busting song.

Eventually, physicists were able to wring the last few degrees out of matter.Â And, as Kelvin predicted, there are no below zero temperatures on his scale.Â It is now possible to get within millionths of a degree above absolute zero, and it turns out that he was only off by half a degree!

That's impressive.Â It seems that Lord Kelvin had his temperature scales down cold.

There's cold, and then there's c-c-c-cold.Â It's all relative, or is it?
Credit: morguefile.com

Click here to read a previous Chemical Eye On

Chemical Eye on Bond Ratings

I don't pay much attention to the bond ratings in the P & S index, because I know that most of them are highly subjective.Â On the other hand, I had always assumed that the bond ratings in the S & P Index were completely objective.Â When I found out that they were bogus too, I could only wonder what will we call the dismal science now?

Like derivative financial contracts and credit default swaps, the previous paragraph was intended to be confusing.Â Sorry about that--but I'm pretty sure that I didn't wipe out anyone's 401(k). Â

In case you didn't notice, I was trying to cleverly contrast chemistry and economics.Â You see, "P & S index" is a reference to the annual indices of articles that were published between 1976 and 1988 in the international chemistry journal "Phosphorus and Sulfur" (with the growing importance of semiconductors, it has since been renamed "Phosphorus, Sulfur and Silicon and the Related Elements ").Â And "bond ratings" is my tongue-in-cheek way to acknowledge the frustrating fact that chemists have vocabularies that often are more reflective of which school of thought they subscribe to, than of the molecules they are trying to describe.

Whereas we all know what the S & P Index is.Â It is one of the reasons your 401(k) has taken a nosedive.Â At least that is how I interpret the congressional testimonies that were given by leaders of the major bond-rating agencies, including Standard and Poor's, during a post-financial collapse grilling by the U. S. House Committee on Oversight and Government Reform last October.

It seems as though the financial markets were deregulated to the extent that there was overlap between the people developing the mathematical models needed to calculate the financial risk of a complexly structured financial contract, such as a mortgage-backed bond, and the people who were designing the complexly structured financial contracts.

In chemistry, when two atoms collide, and the formation of a new chemical bond is energetically favorable, the odds strongly favor the chemical reaction going forward.Â We can be very thankful that all chemical reactions, whether they occur in the atmosphere or in our blood cells, are highly regulated by so-called rate laws .Â For a given set of conditions, such as temperature and pressure, every reaction has its own rate constant, which only depends on the nature of the bonds to be made and/or broken.Â It is independent of the on-hand supply of reactants as well as the demand of products by a graduate student's research supervisor.

In other words, somehow the molecules "know" what they're doing, and they are not influenced by money or performance evaluations.

In economics, and in the modern financial services industry in particular, the situation seems to be almost the opposite.Â People are buying and selling bonds, many of which have become so complicated that nobody understands them, and people are definitely influenced by money and performance evaluations. Â

For this system to be functional, there must be a means of assigning a risk value to each financial product that cannot be manipulated.Â Whether it was intentional or not, the system failed catastrophically because bond ratings became grossly inflated.

There is a clear and unsurprising parallel to the phenomenon of grade inflation since university administrators started relying on student evaluations to judge teaching effectiveness.Â But I'll leave that to another day.

In the meantime, I hope that trust and reliability, which cannot exist without highly regulated objectivity, will return to the financial markets.Â After all, there are a lot of college students who will be adversely affected by scarce or expensive credit.Â We would all be the losers if our education system was the next domino to fall.

I also have new reasons to be glad that I am a chemist.Â There has been exactly zero inflation in bond energies, and there are no Ponzi schemes in Erlenmeyer flasks.

hear the audio: http://www.publicbroadcasting.net/wmot/news.newsmain?action=article&ARTICLE_ID=1455833

If bond ratings were as straight-up as Wall Street itself, the credit crisis might have been averted.
morguefile.com

Click here to read a previous Chemical Eye On

Â
Read more of the Chemical Eye On series
Articles are listed chrnologically, to jump to one click on a link below: