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A New Lab? A New Country?

China Lab Tournament Opens Eyes

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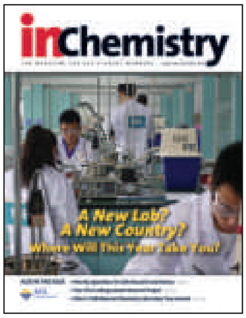

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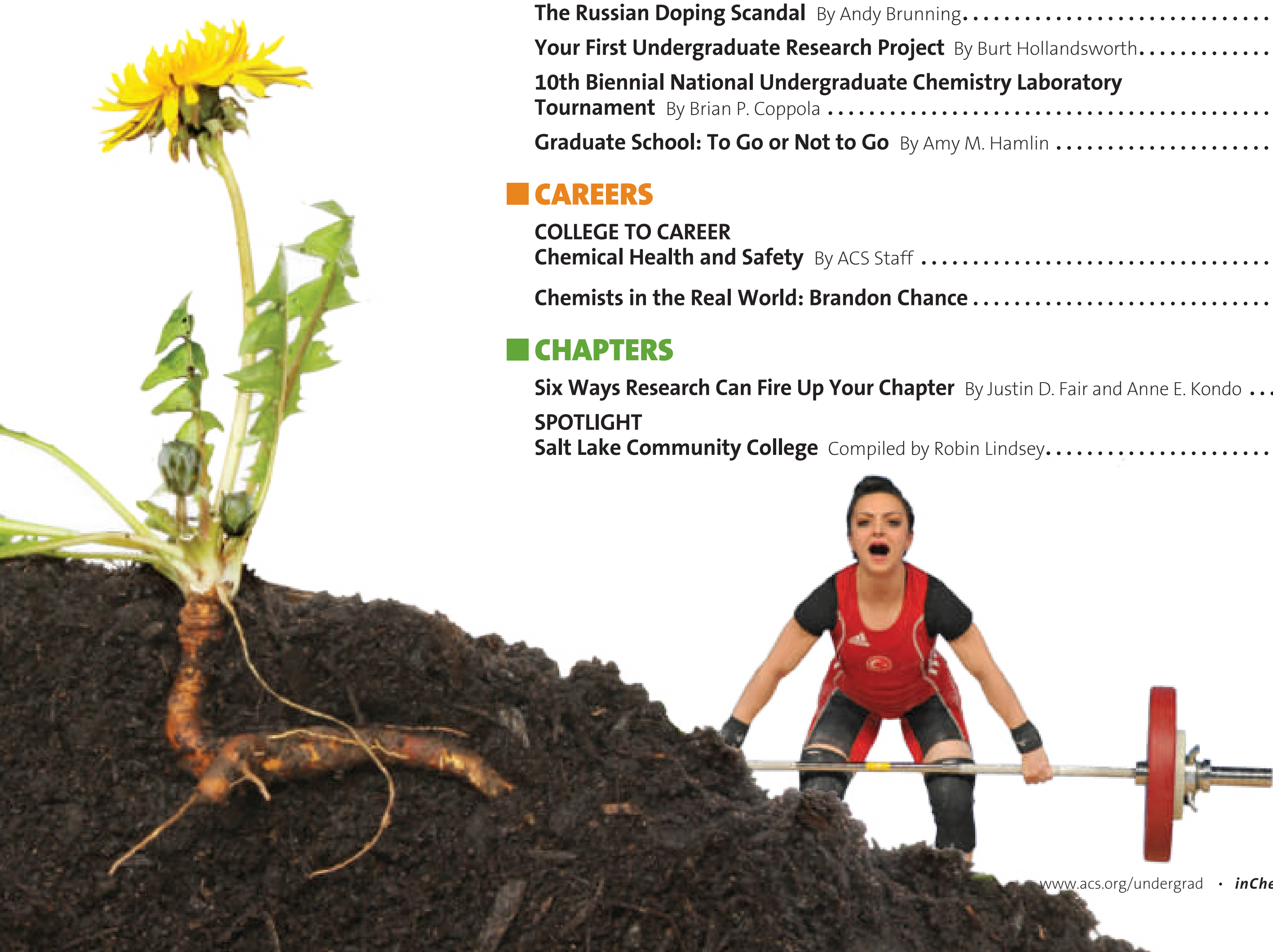

EDITORIAL:
Doing Chemical Demonstrations Safely

BY DAVID C. FINSTER

SHUTTERSTOCK

Chemical demonstrations can be fun for grade school students who find color changes and other features of chemical "magic shows" interesting and mysterious! Sadly, there have been situations where students watching such demonstrations were severely injured.

The same features that make many demonstrations exciting can also make them dangerous, so it's important to think about both the value of each chemical demonstration and the conditions for conducting them safely.

When you're doing outreach demonstrations, you're not only entertaining people, you're also teaching them chemistry. Demonstrations can be followed with questions like "Why did that happen?" or "What must be happening at the molecular level?" Or you can ask audiences to make predictions, such as "What do you think will happen when...?"

The worst outcome is not that some demonstration might not work as planned; it's that someone could get injured. It is important to send the message that chemistry can be both exciting and safe — so long as the proper precautions are taken.

Incidents that have made the news recently have involved unexpected flash fires in the "Rainbow" demonstration. Traditionally, metal salts are dissolved in methanol, and the flame from the burning methanol produces colors associated with electronic transitions in the vaporized metal atoms. This is a variant of what happens in fireworks. Because methanol burns with an almost invisible flame, it is easy to assume that the flame is extinguished when it's actually still lit. If the demonstrator adds more methanol (usually from a large bottle), the vapors from the bottle are ignited and cause a jet of burning methanol to shoot out of the bottle. This flame can be projected several feet, and the demonstrator can easily drop the bottle, leading to a large flash fire. In many instances where this has occurred, students have suffered very serious burns.

To protect your audience (and yourself) from potential hazards, a little forethought goes a long way. A common paradigm in chemical safety is summed up in the mnemonic RAMP: Recognize hazards, Assess risk, Minimize risk, and Prepare for emergencies. Here's how you can apply these guidelines to the "Rainbow" demonstration:

- **RECOGNIZE** that methanol is extremely flammable.
- **ASSESS** that the risk of flash fires and other severe hazards is very high when methanol is intentionally ignited (as opposed to using methanol only as a solvent, with no source of ignition, which would have a rather low risk).
- **MINIMIZE** the risk in two ways: (1) redesign the experiment to avoid the use of methanol[1,2] or (2) make sure that only small volumes of methanol are present and that the room conditions allow the flame to be seen. The second revision removes the large bottle of methanol and also prevents additional methanol from being added to an already lit fire. In addition, a safety shield should be used as a barrier between the demonstration and the audience, and the audience should be kept at a safe distance.
- **PREPARE** for emergencies by, in this instance, having an appropriate fire extinguisher handy.

When you are doing a chemical demonstration, it should be under the supervision of a faculty member. But, as part of your chemical education, you should think about RAMP for each demonstration you conduct. By doing so, you can make sure that the happy outcomes of entertainment and education are not compromised by a flawed or dangerous demonstration.

Best wishes for your next chemistry demo!

For more information about chemical safety, visit **www.acs.org/safety**. iC

David C. Finster *is professor of chemistry and the chemical hygiene officer at Wittenberg University. He is a co-author of* Laboratory Safety for Chemistry Students *(Wiley, 2016) and a member of the ACS Committee on Chemical Safety.*

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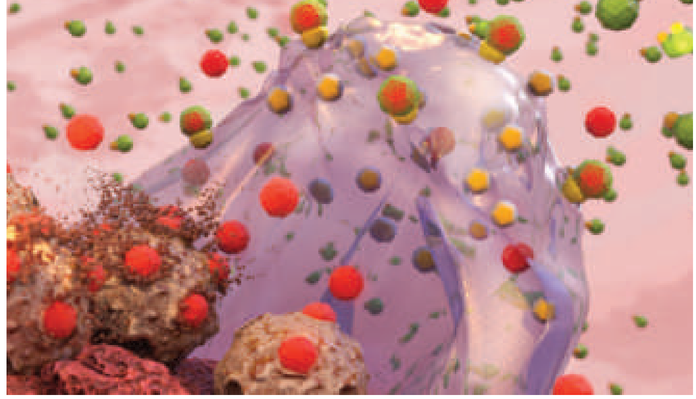


ATOMIC NEWS

COMPILED BY JESSICA ROBERTS

Source: ACS Office of Public Affairs Weekly PressPac, www.acs.org/news

Molecular shields reduce chemo side effects

Sarcoma is an aggressive form of cancer responsible for up to 20% of childhood cancers. Tumors often first appear in the extremities and the abdomen. Surgery is a primary treatment, but it is often combined with chemotherapy. In a recent issue of *ACS Central Science*, researchers propose a scheme to target chemotherapy medications specifically to sarcomas, leading to greater efficacy and fewer side effects.

Jose Mejia Oneto, Max Royzen, and colleagues developed a technology that shields a toxic and commonly used chemotherapeutic, doxorubicin, until it comes into contact with an activating agent held at the tumor site by a polymer material. While both the traditional delivery of doxorubicin and the new approach were successful in the initial treatment of sarcoma tumors in mice, only the site-activated drug kept the cancer from coming back. In addition to a better therapeutic outcome, the local activation strategy had fewer side effects. In particular, the researchers did not observe a decrease in new red blood cells, a marker of bone marrow suppression, which limits the tolerable dose in patients. Other unpleasant side effects, such as weight loss or changes in hair, were not observed compared with those treated conventionally. The authors intend to leverage the lower toxicity of their treatment to investigate whether shorter courses of their therapy using higher doses are even more effective, and expand this approach to other solid tumors and drugs.

The authors acknowledge funding from the National Science Foundation, State University of New York at Albany, and Shasqi.

Read more about the research: "In Vivo Bioorthogonal Chemistry Enables Local Hydrogel and Systemic Pro-Drug to Treat Soft Tissue Sarcoma," *ACS Central Science*, 2016, 2(7), pp 476–482.

www.acs.org/news

4

Espresso machines **could speed up experimentation**

Many chemists are familiar with taking late-night trips to the espresso machine. These excursions were undertaken merely for the caffeine boost… until now! Recently, a group of scientists reported in the ACS journal *Analytical Chemistry* that espresso machines can be a low-cost alternative for testing for harmful compounds in the environment.

Polycyclic aromatic hydrocarbons (PAHs) are a class of carcinogenic organic compounds that are ubiquitous in the environment. They are generated by incomplete combustion of materials in forest fires, industrial plants, and waste incinerators. Current methods of determining the levels of PAHs in soil are time-consuming and require hazardous solvents or expensive equipment. An espresso machine quickly runs hot liquid through coffee, so Francesc A. Esteve-Turrillas and colleagues set out to determine whether using an espresso machine with soil (instead of coffee) could efficiently extract PAHs for further analysis.

The group percolated a soil sample in an espresso machine with a small amount of organic solvent and water. The extracted sample was then analyzed via chromatography to determine the amount of PAHs present. It took just 11 seconds to complete the process. The results from the espresso procedure were comparable to those obtained with certified techniques, yet the coffee machine procedure is significantly faster and less expensive. The researchers concluded that espresso makers can be used as low-cost alternatives in chemistry labs. They are currently testing to see whether these machines can extract and analyze pesticides, pharmaceuticals, and detergents in food and environmental samples.

The researchers acknowledge funding from Spain's Ministry of Economy and Competitiveness and the Generalitat Valenciana (government of Valencia).

Read more about the research: "Hard Cap Espresso Machines in Analytical Chemistry: What Else?" *Analytical Chemistry*, 2016, 88(12), pp 6570–6576.

36 *Percentage of U.S. chemistry majors who voted in the 2012 election, compared with the 45% of all college students who did so, according to the National Study of Learning, Voting, and Engagement at Tufts University*

1669 ***Year in which the element phosphorus was discovered by Hennig Brand, the earliest known discoverer of an element***

1819 **Year in which Friedlieb Ferdinand Runge isolated a relatively pure form of caffeine**

109 The length in miles of all the DNA in your body if uncoiled and laid end to end

21 The hypothetical height in meters of a cube made from all the gold thought to exist on Earth

PHOTO OF PATCH: WANG LAB

Electronic skin patch detects alcohol level in sweat

Drinking too much alcohol can lead to errors in judgment, like driving while intoxicated. To help imbibers easily and quickly know when they've had enough, researchers have developed a flexible, wearable patch that can detect a person's blood alcohol level from their sweat. The monitor, reported in the journal *ACS Sensors*, works quickly and can send results wirelessly to a smartphone or other device.

Every 53 minutes someone dies in an alcohol-related car accident in the United States, according to the Centers for Disease Control and Prevention. Currently, ignition interlock devices are being marketed as a way to prevent drunk drivers from starting a car engine; however, they are based on breath analysis, which can be affected by a number of factors, including humidity, temperature, and even whether someone has used mouthwash. Recent research has demonstrated that sweat can be a more reliable, real-time indicator of blood alcohol content. While transdermal sensors have been developed to measure alcohol levels in sweat, they can take up to 2 hours to produce results. Joseph Wang, Patrick Mercier, and their colleagues at the University of California, San Diego, set out to make a more practical version.

With temporary-tattoo paper, the researchers developed a patch that tests blood alcohol content in three rapid steps. The patch induces sweat by delivering a small amount of the drug pilocarpine across the skin. The ethanol in the generated sweat is then measured by amperometric detection using the alcohol oxidase enzyme and the Prussian Blue electrode transducer. A flexible electronic circuit board transmits the data via a Bluetooth connection to a mobile device or laptop. The test takes less than 8 minutes from start to finish. In addition to connecting to vehicles' ignition interlock systems, the sensor could be a simple tool for bartenders, friends, or law enforcement to use.

The authors acknowledge funding from the National Institute of Biomedical Imaging and Bioengineering, the Defense Threat Reduction Agency, and the University of California, San Diego, Center for Wearable Sensors.

Read more about the research: "Noninvasive Alcohol Monitoring Using a Wearable Tattoo-Based Iontophoretic-Biosensing System," *ACS Sensors*, 2016, Article ASAP. **http://pubs.acs.org/doi/abs/10.1021/acssensors.6b00356** (Accessed August 25, 2016)

Dandelions could be a **sustainable source of rubber**

While most farmers are actively trying to kill weeds, a team of researchers, led by Katrina Cornish at Ohio State University, are trying to grow them — fast. *Taraxacum kok-saghyz*, a special variety of dandelion from Kazakhstan — nicknamed "Buckeye Gold" — may be the answer to sustainable, U.S.-based rubber-making. An article in ACS's weekly newsmagazine, *Chemical & Engineering News* (*C&EN*), examines the plant's potential for revolutionizing the rubber industry.

While it might look like a regular dandelion, this variety's roots contain 10-15% natural rubber. The goal is to cultivate these dandelions to the point where they can become an industrial rubber crop. Currently, rubber trees that grow on plantations in Thailand, Indonesia, and Malaysia take years to grow, making it hard for producers to adapt to changes in the market. Also, transporting the material is costly to both the industry and the environment. With Buckeye Gold, crops can be grown locally, and they mature much faster than rubber trees.

Current methods make it difficult to scale up dandelion cultivation to be competitive with the well-established rubber industry. Researchers are looking to modify these dandelions using CRISPR/Cas9 gene editing so they can withstand disease and pest-control measures, which would otherwise kill them. Also, because the plant's root has only small amounts of rubber in it, researchers will have to find ways to use the rest of the crop in order for it to be truly sustainable.

Read more about the research: "Dandelions, the Scourge of Lawns, May Be a Fount of Rubber," *Chemical & Engineering News*, 2016, 94(30), pp 28–29.

http://cen.acs.org/articles/94/i30/Dandelions-scourge-lawns-fount-rubber.html

Assessing Risk: *Five Key Questions for Safe Research and Demos*

BY SAMUELLA SIGMANN AND RALPH STUART

After you have taken a couple of chemistry classes, it might seem that the safety rules you reviewed on the first day ("Wear your goggles", "Use the hood when you need to") told you everything you need to know about working safely with chemicals.

When you start working with chemicals on your own — whether in a research lab or in a chemistry demonstration before an audience — the safety situation changes. In teaching labs, someone has already identified the hazards and lowered the risks as much as practical prior to your arrival. But research work requires that you explore new ideas and deviate from established experiments, which can introduce new hazards.

Meanwhile, chemistry demonstrations can take place outside the controlled environment of the lab, which can expose both you and your audience members to a variety of new risks.

Both ethics and self-preservation require you to consciously consider what unexpected results might arise in either situation (see The Chemical Professional's Code of Conduct at **www.acs.org/content/acs/en/careers/career-services/ethics/the-chemical-professionals-code-of-conduct.html**).

There are legal implications, too. Many states adhere to the National Fire Protection Association's recommendation that educators conduct documented risk assessments prior to demonstrations or when students are using hazardous materials in laboratories.[1]

Learning to assess and address risk is vital to your academic and professional career.

The following five questions will help you develop your risk assessment skills and increase your understanding of chemical hazards. You should always document your answers to these questions in writing so that you can explain them to others as the need arises.

1. *What specific chemical or physical reactivity hazards are associated with the way I'm using these chemicals?*

Risk assessment starts with finding reliable information about your chemicals (see Recommended Websites for Researching Chemical Safety Data on page 8), but you should also consider how you are using them. Sometimes simple substitutions of the chemicals in a process or changing the amount or concentration of the chemicals being used can create a different risk scenario. Explosions at the University of Minnesota and Texas Tech University are evidence of the hazards associated with even small changes in the chemistry being studied.[2, 3]

Safety Data Sheets (SDSs) don't always provide specific information about these changes because manufacturers of chemicals can't predict all the ways researchers will use them. Remember that the phrases "Not Available" and "No Information" do not mean "Safe." Consulting information resources beyond the SDS is important any time you (1) change the chemical or process you're using, (2) increase the concentration of the chemicals you're using, or (3) increase the quantities of the chemicals you're using by a factor of 3 or more.

For physical hazards associated with chemicals, be particularly mindful of chemicals that have a signal word "Danger" with the Globally Harmonized System of Classification and Labelling of Chemicals (GHS) icon of an exploding bomb, oxidizer, or corrosive. For health hazards, be particularly mindful of the skull and crossbones and health hazard icons. If chemicals with these warnings are important to your experiment, be sure to take protective measures, such as using only small quantities and carefully controlling what the chemicals come into contact with.

2. *What type of ventilation do I need?*

In the laboratory, both fume hoods and general room ventilation rely on dilution to control the potentially hazardous vapors from chemicals. If there are likely to be significant emissions of chemicals that you don't want to breathe, you need a fume hood. Remember that fume hoods have to be used correctly to contain vapors and are not meant to control fires, explosions, or particles.[4]

So which chemicals don't you want to breathe? For help in making this determination, consult the SDS to identify toxicity levels and odor thresholds of the chemicals. Look for the phrase "well-ventilated space" in the SDS precautionary statements. Seek advice from your advisor or chemical hygiene officer if you do not know how the data you find apply to ventilation requirements.

Risk Assessment in the Workplace

In industry, "risk assessment" is the process of identifying, evaluating, and mitigating hazards. A grid similar to the one shown below is typically used to estimate risks.

The impact of something going wrong (organized in columns) is combined with the likelihood of it happening (in rows), and a relative risk level is assigned accordingly. For example, if someone is dissolving sodium chloride in boiling water using a stirring rod, an accidental splash is somewhat likely. A boiling- water splash will probably burn (recognized hazard), so this procedure comes with a moderate risk.

LIKELIHOOD \ IMPACT	Negligible	Harmful	Serious
Very likely/ frequent	Moderate risk	High risk	High risk
Somewhat likely	Low risk	Moderate risk	High risk
Unlikely	Low risk	Low risk	Moderate risk

In the workplace, low-risk procedures are preferred. The aforementioned procedure could be made less risky by modifying it to use a stir plate or room-temperature water, for example. Moderate-risk activities are considered carefully, with emergency plans in place ahead of time. High-risk procedures are rarely, if ever, approved because they do not meet legal or code requirements without expensive engineering precautions. iC

3. *What personal protective equipment do I need?*

This is probably the most complicated of the safety questions. First, you must decide what personal protective equipment (PPE) is required for the chemicals and the processes you are using. Your specific PPE needs will depend on how the work is being done.

Consider the following:

Fit. Take the time to find the right size protective equipment for you. If your audience members will need PPE, be sure to have a variety of sizes. Changing the brand may provide a fit.

Gloves. The width of your hand across your knuckles, in inches, is your approximate glove size. Gloves should be tight enough to move with you and keep out hazards, but they should not be so tight that they tear easily or weaken the material.

Eyewear: Goggles should provide a complete, snug seal around the eyes and the bridge of your nose. If they are too loose, hazardous liquids could splash in. If they are too tight, they may fog. If you wear eyeglasses, look for goggles sold as "OTG" (over the glasses).

Lab coat. A lab coat should cover from your arms to your wrist and fall past your knees. It should be just large enough to cover your torso when fastened without gapping or restricting movement. Loose sleeves can create a spill hazard; rolled-up sleeves can trap chemicals. A lab coat that is too large can trip you, become caught on equipment, or leave your neck area open for spills.

Type. Generally, if there is a possibility of a chemical splash of more than 100 mL, then you need chemical splash goggles with indirect venting. If you are using instrumentation or doing computer work in the lab, safety glasses may suffice.

Material. Chemicals can permeate all glove materials, eventually. The "permeation time" can help you decide which material is best for your chemicals. If you cannot find a specific material for your chemical, it may make sense to wear two pairs of gloves and replace the outer gloves whenever they show signs of contamination or tears. Likewise, when working with flammable solvents or demos that involve fire, you need a flame-resistant coat that provides coverage to, at least, the knees. A rubber apron might be needed if you are working with larger quantities of corrosive liquids.

4. *What emergency response protocols will be needed if something goes wrong?*

Chemistry laboratories will have spill kits, fire extinguishers, eyewashes, and safety showers available — but do you know how to use them? An emergency is not the time to figure out how they work, so ask your faculty advisor for a chance to try them before you need them.

Working with certain chemicals requires special planning in case of a spill or exposure. Some chemicals can penetrate the skin's surface and impact other organs of the body, such as the kidneys, heart, and nervous system. Deaths have resulted when lab workers spilled very hazardous chemicals on their skin and lacked the proper first-aid resources to treat the exposure. Look for the phrase "Specific Target Organ Toxicity" on the SDS for any chemical marked with the GHS skull and crossbones icon to identify chemicals with this potential. Whenever using such chemicals, special training, adequate ventilation, and the correct PPE are imperative for safe use.

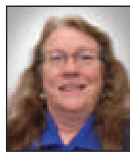
Ball State University Regional Science Fair

5. *What will I do with the waste?*

Laboratory work can generate many different kinds of wastes. Some of the most common among them are chemicals, sharps, biological wastes, and radioactive wastes. For practical and legal reasons, these cannot be disposed of in the sink, trash, or recycling system. Very little information on this topic will be present on SDSs because laboratory wastes are regulated differently from location to location. For this reason, your institution will have its own system to ensure the safe collection and disposal of hazardous wastes. Labeling of waste is strictly regulated by the Environmental Protection Agency, so it's important that you understand your institution's requirements.

Be sure to know which protocols apply to any waste materials you will generate before you start work. The mixing of incompatible materials in waste containers is very dangerous and can result in the container rupturing. As with an emergency, you don't want to be thinking "Where does this go now?" or "Can I mix these?" after you have already generated the waste.

After taking a couple of chemistry courses, you are probably feeling pretty safe around chemicals; however, recent fires, explosions, and other incidents should remind you that even familiar materials can become dangerous if you are not prepared. Fortunately, learning to ask and answer the questions listed above before proceeding with laboratory work or chemical demonstrations during your undergraduate years will advance your thinking about safety from merely following rules to managing risk. This good habit will be a powerful advantage as you make the transition from a student in teaching labs to a chemist in research and demonstration settings. iC



Samuella Sigmann *and* **Ralph Stuart** *serve on the ACS Committee on Chemical Safety. Sigmann is the chemical hygiene officer for the chemistry department and an analytical chemistry lecturer at Appalachian State University (NC). Stuart is the chemical hygiene officer at Keene State College (NH) and Secretary of the ACS Division of Chemical Health and Safety.*

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Chemical Safety Data Resources

Laboratory Chemical Safety Summary (LCSS) in PubChem

https://pubchem.ncbi.nlm.nih.gov/lcss

Developed by the National Center for Biotechnology Information

CAMEO Chemicals

https://cameochemicals.noaa.gov

Set up by the National Oceanographic and Atmospheric Administration

Safety Resources

Hazard Assessment in Research Laboratories

A collection of methods and tools for assessing hazards in research laboratories

www.acs.org/hazardassessment

The Safety Zone

Covers chemical safety issues in academic and industrial research labs as well as in manufacturing

http://cenblog.org/the-safety-zone

Lab Safety Quiz

A quiz based on the ACS pamphlet *Safety in Academic Chemistry Laboratories*

www.stolaf.edu/depts/chemistry/safety

FITS LIKE A GLOVE

Choosing the Right Glove for the Job

What part of your body is most exposed to chemicals in lab work and demos?

Your hands, of course!

Protecting them with gloves is quick and easy, if you know which type to use.

POLYETHYLENE

Advantages:

- Excellent protection from common acids and bases
- Inexpensive

Disadvantages:

- Limited tear resistance

Good protection from:

- Acids
- Detergents
- Common dilute lab reagents

Poor protection from:

- Concentrated reagents and solvents

NEOPRENE

Advantages:

- High density
- Tear resistant

Disadvantages:

- Impaired dexterity

Good protection from:

- Peroxides
- Fuels
- Alcohols
- Organic acids and bases

Poor protection from:

- Halogenated compounds
- Aromatic compounds

NITRILE

Advantages:

- Flexible
- Sturdy
- Easy to see punctures

Disadvantages:

- Limited chemical protection

Good protection from:

- Oils and greases
- Acids, caustics
- Alcohols
- Chlorinated solvents

Poor protection from:

- Strong oxidizing agents
- Aromatic solvents
- Ketones
- Acetates

BUTYL

Advantages:

- Sturdy
- Reusable

Disadvantages:

- Limited sizes
- Impaired dexterity

Good protection from:

- Peroxides
- Strong acids and bases
- Alcohols
- Aldehydes
- Ketones
- Esters
- Nitro compounds

Poor protection from:

- Hydrocarbons (aliphatic, aromatic)
- Halogenated solvents

LAMINATE FILM

Advantages:

- Protection from a wide variety of chemicals
- Can be a liner under other gloves
- Good dexterity
- Good for hazmat work

Disadvantages:

- Not puncture-resistant

Good protection from:

- Alcohols
- Hydrocarbons (aliphatic, aromatic)
- Chlorines
- Ketones
- Esters

Poor protection from:

- Check manufacturer information

Individual brands vary. Always check glove compatibility against the manufacturer's recommendations.

Special thanks to the ACS Committee on Chemical Safety.

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www.osha.gov/Publications/osha3151.html
www.ehs.berkeley.edu/workplace-safety/glove-selection-guide

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Athletes at Rio Olympics Could Face Advanced Antidoping Technology

From *Chemical & Engineering News*

BY SARAH EVERTS

Athletes who attended the Summer Olympics in Rio de Janeiro may eventually face a new kind of doping test: one that checks whether they have received performance-enhancing gene therapy. According to the International Olympic Committee's medical and scientific director, Richard Budgett, samples collected in Rio will be tested for gene doping at some point, even though the test was not run during the Olympics itself.

Officials want to know whether athletes have been given synthetic DNA that codes for erythropoietin (EPO), a hormone that increases red blood cell production and, consequently, athletic performance, said Carl Johan Sundberg, an exercise physiologist at Karolinska Institute and member of the World Anti-Doping Agency's gene doping panel. Sundberg explained the technique that Olympic officials plan to use to test for gene doping at the EuroScience Open Forum (ESOF) conference, held July 23–27 in Manchester, England.

Retroactive testing isn't good news for doping athletes. When scientists retested fluid samples from athletes competing at previous Olympics Games, namely Beijing's 2008 and London's 2012 Summer Games, many more athletes tested positive for banned substances than with prior analyses. The tests, carried out with improved analytical techniques, revealed that, on average, 8% of the athletes at those two games actually tested positive for banned substances, up from an average of less than 1% observed in past games. The increase is "sensational," said Arne Ljungqvist, a 1952 high-jump Olympic athlete and former vice president of the World Anti-Doping Agency (WADA), at the ESOF session.

Add these data to other recent doping scandals, and the International Olympic Committee (IOC) has had its hands full lately. In July, the IOC announced that Russian athletes could participate in the Rio Games, despite evidence of sample tampering at the 2014 Sochi Winter Olympics and indications of an entrenched doping culture in the country's athletic community.

It is not known yet whether WADA doping labs found any athletes guilty of gene doping at the Rio Olympics. Just before the start of the Olympics, there was no evidence that Olympic athletes had undergone gene doping, according to Sundberg. But then again, "the test has never been used before," he added.

Even so, evidence does exist that at least one German coach tried to organize gene doping for his athletes more than a decade ago: In a 2006 trial, prosecutors exhibited e-mails written by former German Athletics Association coach Thomas Springstein in which he requested EPO gene doping products from his drug dealer.

Although only a handful of gene therapy procedures to treat disease have been approved by worldwide regulators, WADA started considering the possibility that athletes might abuse gene doping in 2002, and in 2003 it added gene doping to its list of prohibited substances and methods.

Turkish weight lifter Sibel Özkan was recently stripped of the silver medal she won at the 2008 Beijing Olympic Games after retesting showed that she had doped.

PHOTO: XINHUA / ALAMY STOCK PHOTO

The gene doping test is based on work by Anna Baoutina and colleagues at the National Measurement Institute in Sydney, Australia. The technique relies on the gene that naturally codes for EPO in the human body and the fact that it contains four introns, sequences that get cut out of messenger RNA after the gene has been transcribed. Synthetic EPO DNA inserted during gene therapy is unlikely to have such intron sequences. Gene dopers could be caught if officials scanned blood samples for EPO DNA without these introns.

This is not the only strategy proposed for checking athletes for gene doping. Researchers have also designed tests that search for proteins in blood that are unique to the viruses scientists use to transport genes across a cell membrane and then into a genome (*Drug Testing Analysis* 2012, DOI: 10.1002/dta.1347). Other techniques rely on looking at the sugars bonded to the exterior of the protein (also known as "decoration") that's been produced from the contraband. For example, EPO is normally produced in the kidney, where it is glycosylated in four different places.

Gene dopers, however, are more likely to inject EPO DNA into muscle, which has different glycosylation pathways. Unusual sugar decorations could act as a smoking gun for gene doping, Sundberg said. In fact, doping labs currently do an analogous test that looks for athletes who have injected bacteria-synthesized EPO directly into their blood, he added. Bacteria decorate EPO differently than humans do, giving testers a way to catch cheaters.

WADA is also funding research to test whether athletes have received gene therapy for growth factor proteins, such as growth hormone and IGF-1, which bolster muscle development. The doping research field is also investigating ways to test for anticipated cell doping in athletes, Sundberg said. Doctors have for a long time transplanted bone marrow stem cells in cancer patients, he said. "In the future, athletes may transplant cells to improve heart and muscle strength and endurance." And with the advent of the CRISPR/Cas9 technique, athletes could start paying for genetic editing of their own cells. "You might think it sounds like a bit of science fiction, but it might quite soon not really be so," Sundberg said.

"Although researchers are trying to anticipate future doping strategies, steroids are currently still the number one choice for doping athletes."

Although researchers are trying to anticipate future doping strategies, steroids are currently still the number one choice for doping athletes, Ljungqvist said at ESOF.

The spike in positive doping results that scientists saw when they retested samples from Beijing and London, for instance, can be attributed to steroids. Researchers have made improvements in analytical instruments — primarily mass spectrometers — for detecting contraband compounds, and they've discovered so-called long-term metabolites of banned anabolic steroids, including metandienone, oxymetholone, and stanozolol, in athletes' urine.

In the past, researchers could only detect metabolites of a banned steroid in urine for weeks after the last dose, Ljungqvist explained. "Now that window has been expanded to a couple of months" with the identification of these metabolites that stick around much longer.

After a WADA-accredited laboratory in Cologne, Germany, started testing for long-term metabolites of metandienone, the lab saw a 400% increase in positive doping results (*Br. J. Sports Med*. 2014, DOI: 10.1136/bjsports-2014-093526).

"In the future, athletes may transplant cells to improve heart and muscle strength and endurance."

Although most media attention focuses on doping by professional athletes, there's also a growing doping problem among the general public, Ljungqvist said.

"Nine-tenths of the iceberg underwater is the doping taking place in recreational sports or by people trying to enhance their body image in entirely unregulated ways," said doping researcher Mike McNamee from Swansea University to the ESOF delegates.

"It's not just young men wanting to look like their favorite Hollywood actor. It's also policemen, firefighters, security personnel, and bouncers," he said. Although everyone working in doping agrees it's a huge problem among the general public, there's no reliable prevalence data, McNamee said. Because it's not possible to test the general public for contraband drugs — except in Denmark, where doping officials are allowed to test people in public gyms — education is probably the best way to reduce the use of contraband drugs by the general public, McNamee added.

Of course, it's hard to convince the general public not to use contraband substances if professional athletes caught doping don't suffer consequences.

"I am one of those who was fooled in Sochi by the Russians," Ljungqvist told reporters during a press conference at ESOF. "At night, behind my back, [they] were changing samples through a hole in the wall. This is not the first time I was cheated by the Russians. During the Beijing Games, we discovered that female athletes' urine was exchanged. This deserves some punishment." When asked about the IOC's decision not to ban Russian athletes from participation in Rio, Ljungqvist replied, "In the IOC report, I would have welcomed an explanation about why this penalty wasn't chosen."

To read more from or subscribe to *C&EN*, visit **cen.acs.org**. iC

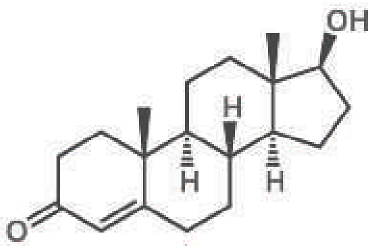
The original version of this article first appeared in the ACS weekly newsmagazine, Chemical & Engineering News *(C&EN). "Athletes at Rio Olympics Face Advanced Antidoping Technology,"* Chemical & Engineering News*, 2016, 94(32), pp 25-26.* **http://cen.acs.org/articles/94/i32/Athletes-Rio-Olympics-face-advanced.html**

Periodic Graphics

A collaboration between C&EN and Andy Brunning, author of the popular graphics blog **Compound Interest**

THE RUSSIAN DOPING SCANDAL

Months before the Rio Olympics, Russia's former antidoping lab director told the *New York Times* he covered up doping at the 2014 Sochi Games. Here, we look at the drugs allegedly used.



TESTOSTERONE

ANABOLIC STEROIDS

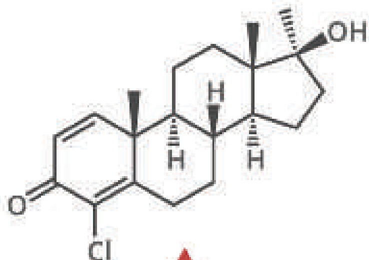
Anabolic (or anabolic-androgenic) steroids are drugs that have similar structures to testosterone and mimic its effects in the body. They help athletes increase muscle mass. And although they are banned by all major sports bodies, they are the most frequently detected doping substances in sports.

FAILED TESTS IN 2014

148 REPORTED
BY THE WORLD ANTI-DOPING AGENCY

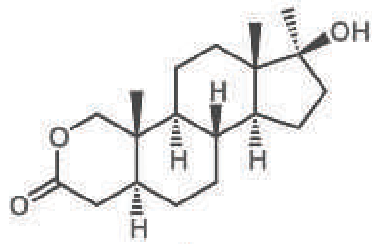
If a Russian sample-swapping operation had not replaced tainted urine samples with clean ones, then this figure would likely be higher.

"THE DUCHESS": A COCKTAIL OF THREE ANABOLIC STEROIDS

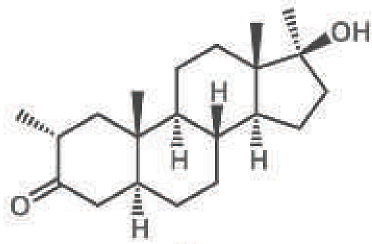


ORAL TURINABOL

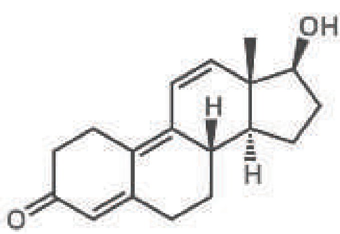
Switched to trenbolone (below) after the 2012 London Games

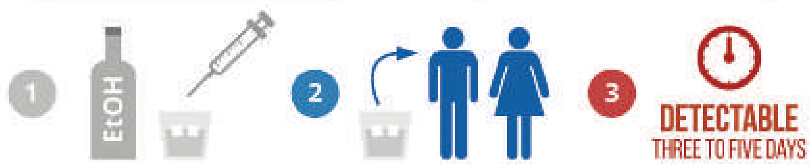


OXANDROLONE



METHASTERONE



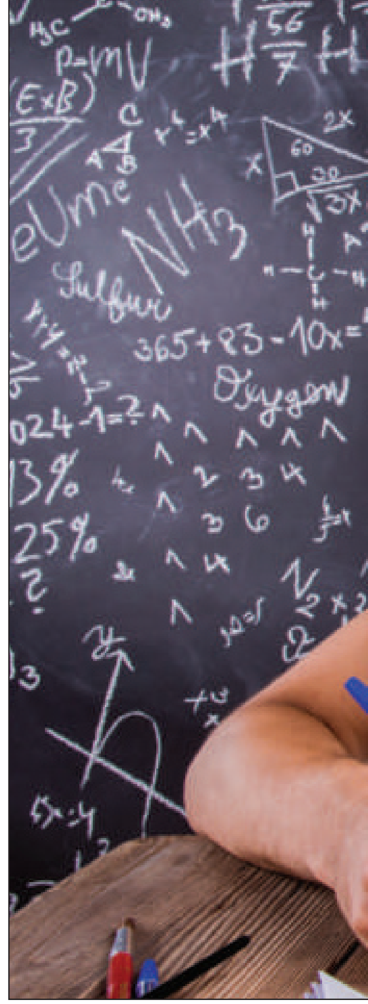


Russia's former antidoping lab director says he mixed the steroids with alcohol so they'd dissolve more readily. Athletes swished the mixture in their mouths then spit it out. Absorption through the cheek lining shortened the window during which the steroids could be detected.

More online

To see more of Brunning's work, go to **www.compoundchem.com**.
To see all of C&EN's Periodic Graphics, visit **http://cen.acs.org/periodicgraphics.html**.

FEATURE



Your First Undergraduate Research Project

BY BURT HOLLANDSWORTH

So, you've been thinking about undergraduate research in the chemical sciences. Perhaps your program requires you to do a semester (or more) of independent research. Or maybe you have enjoyed chemistry and want to learn more about the discovery process. Perhaps your favorite professor has been hounding you since freshman year to stay at school one summer and do some organic synthesis.

Whatever the reason, an undergraduate research project is a good idea. Research can help you process and use what you learned in your chemistry courses. Plus, the hands-on chemistry process can be incredibly rewarding; for many chemists, there is no more fulfilling experience than doing one's part to design and implement experiments that answer a scientific question. But before you begin the project, even before you start looking for an advisor, there are some important questions you may want to ask yourself.

What kind of research is best for me?

Research projects tend to fall somewhere on the spectrum between "basic" and "applied."

Basic research is designed to answer an interesting question about nature — for instance, "Is it possible to make a 1,3-substituted pyrazole starting with hydrazine and a diketone?" The researchers may not even have an end use for pyrazoles, but they may still believe that finding a novel way to make pyrazoles contributes to the existing body of knowledge about chemistry.

Applied research, on the other hand, focuses on the development of a new technology or method to be used for a specific purpose. Applied research often centers on discovering new scientific knowledge regarding the application of a product, process, or service. A good example would be, "Is it possible for us to develop a method to find peroxide explosives on clothing at a parts-per-billion level using mass spectroscopy?" Applied research projects have more specific goals than those involving basic research and lead to more applications in the real world.

If you want to be able to explain a tangible application of research, you should probably pursue a more applied project. If you are more interested in learning something new and exciting for its own sake, either applied or basic research might work well. Often, professors will have ideas for projects that span the continuum between applied and basic research.

In which area should I do research?

There is no chemistry research project that works equally well for all students. For example, if you hate column chromatography or find carbon-based chemistry dull, then organic synthesis might not be a good choice. Likewise, if you are exploring the chemical phenomena associated with a particular instrument and want to fine-tune its use, you might prefer research involving analytical chemistry.

"Research during the semester will be a good test of your ability to juggle multiple responsibilities."

SHUTTERSTOCK

Many professors are both teachers and researchers, and many can design undergraduate projects related to chemical education for students who plan to teach. You can also suggest a project topic to one or more faculty members at your institution. You might be surprised when they are able to find a connection between your interests and ideas of their own. They may even want to collaborate with another faculty member to advise you on a cross-disciplinary project.

Keep in mind that some advisors might require that you complete some prerequisite coursework before starting research. But this is not always the case; many professors are willing to develop projects for students who have only completed general chemistry.

When should I do research?

If this is your first time doing research, it may be easiest to wait until summer break. Independent research comes with a learning curve — you do not want to put yourself in the position of having to choose between doing research and completing your regular coursework. For a lot of students, summer break provides many continuous weeks to focus solely on your project, free from the distractions of the normal school year.

Another advantage of doing research during the summer is that professors tend to have smaller teaching loads and, therefore, they can devote more time to mentoring undergraduate researchers. Plan to use the last couple of weeks of a project to write up the results of the project in a concise document, with the aim of aiding other students who might continue in the same line of research.

Of course, sometimes curriculum requirements require you to conduct research during the school year. Alternatively, a great research opportunity may arise that cannot wait until summer. If possible, you may want to investigate having a reduced course load if you are conducting research during the school year. Research during the semester will be a good test of your ability to juggle multiple responsibilities. This is not unlike the first few years of chemistry graduate school, where students are required to start graduate research while taking and/or teaching courses.

How do I prepare to do research?

Plan to spend the first few days (or even a week) of your project researching the chemical literature on your topic. This ensures that you are not reinventing the wheel by repeating experiments that have already been completed by others. Use a good literature search program like SciFinder Scholar®, and don't be afraid to search far back in time. Our forebears did some wonderful chemistry in the late 1800s and early 1900s that is often overlooked by anxious investigators. More than one chemist has been surprised to find that their "novel" idea was published long ago. Buy a good notebook, if your research advisor does not provide you with one, and keep detailed notes on all of the methods and chemicals that you find in the literature.

"Keep an eye out for competitive, campus-wide, non-discipline-specific calls for research proposals."

Finally, complete some safety training before starting any undergraduate research project. Hopefully, your institution has a standard safety course required for all research students. If not, ask your advisor to dedicate some time to providing on-site safety training in the chemicals and methods used in their projects. Keep a record of any such safety training on file. This type of training will ensure that you are up to speed on all the hazards associated with your chemicals and equipment, and that you can mitigate them safely.

"More than one chemist has been surprised to find their 'novel' idea was published long ago."

Who is going to pay me to do research?

This is one of the most important questions you might ask about undergraduate research. First, ask your department chair about grants from your institution. Some departments earmark funds from donors to pay for undergraduates to do research on campus. Your advisor or department chair may also be able to arrange for free housing for you if you stay over the summer to do research.

Keep an eye out for competitive campus-wide, non-discipline-specific calls for research proposals. Your faculty advisor might be able to help you identify and write proposals for these types of programs. At larger schools, or at undergraduate institutions with very active research programs, some faculty may have external research grants that they can use for undergraduate research stipends. Last but not least, check with your department chair for a list of faculty with external funding or submitted research proposals.

If you are willing to travel, there are many institutions that actively seek funding for undergraduate research. Go to **www.acs.org/GetExperience** for a guide to undergraduate research that includes a listing of undergraduate research opportunities and International Research Experiences for Undergraduates (IREUs). You will find information on a variety of locations where undergraduate research funding is provided on a competitive basis.

Finally, do not be afraid to seek out and complete a good undergraduate research project. You will find that research provides a sense of accomplishment that is very different from even outstanding achievement in the classroom. You will develop the ability to plan experiments and apply your chemical knowledge to real scientific situations. Undergraduate research projects will do more than pad your résumé; they will provide you with some of the most memorable and meaningful experiences of your undergraduate career! **iC**

Burt Hollandsworth *is a graduate of The Ohio State University, receiving his Ph.D. in inorganic chemistry. He is an associate professor at Harding University in Searcy, AR.*

10th Biennial National Undergraduate Chemistry Laboratory Tournament

BY BRIAN P. COPPOLA

Students from the University of Michigan-Ann Arbor (UM) and the University of Sheffield, UK (USUK) recently participated in China's National Undergraduate Chemistry Laboratory Tournament (NUCLT). Held July 6–10, 2016, at Nanjing University, Xianlin, the tournament celebrated its 10th anniversary by hosting two teams of foreign student participants for the first time.

The event drew three-student teams — all rising seniors — from 43 campuses all over China. More than 200 faculty members attended a concurrent conference to share ideas about laboratory teaching. The students from the University of Michigan and the University of Sheffield participated fully as honorary guests.

"The design of this tournament sends a powerful message about fairness, the true spirit of competition, and getting at the underlying question of how Chinese universities are doing in the laboratory education of their students," says Professor Chengjian Zhu of Nanjing University, one of the chief organizers of the competition. "Another intent we have for this tournament is to continue to encourage our best students to pursue their scientific career interests."

To participate, each school sends the organizing committee a list of at least 30 potential team members, out of which three are chosen at random and notified of their selection about two weeks prior to the tournament. Students are anonymously assigned to one of three groups. On the night before the competition, each faculty representative draws three identifier letter-number combinations at random. During the competition, the participants are only known to the judges as Competitor A24, B06, and so forth.

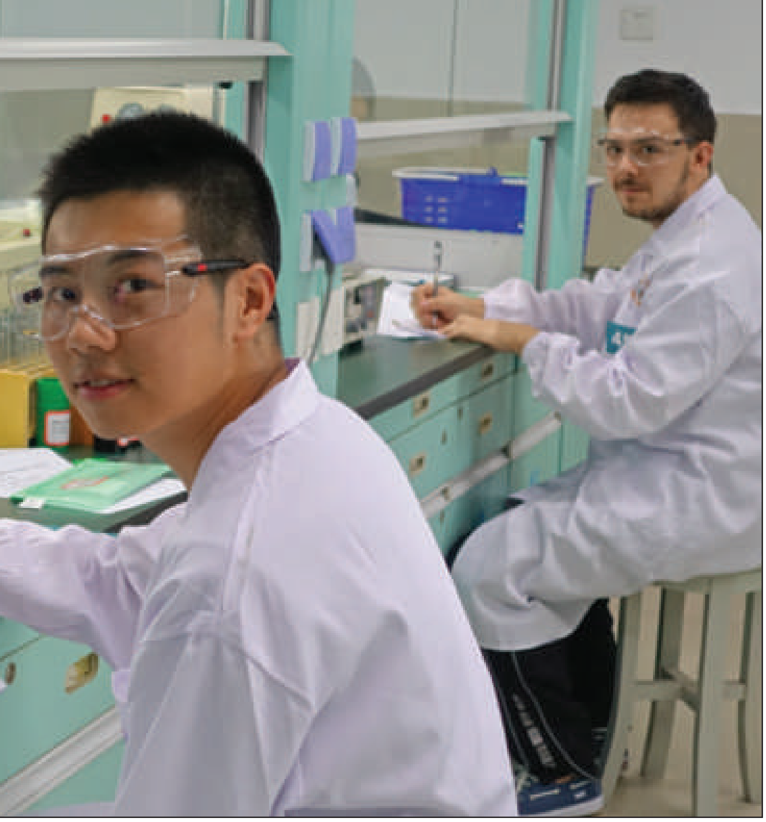
On the first day, all of the students take a 2-hour written examination comprising 77 open-ended questions on laboratory procedures and experimental methods. On the morning of the second day, 30 minutes before the start of the 7-hour practical, a blind drawing is used to assign each group (A, B, C) to a set of organic, physical, or inorganic/analytical experiments. The students spend the day carrying out these procedures under the watchful eyes of the judges.

The UM and USUK students had an appropriately eye-opening experience. As Mike Payne and Qiuhan Li from the UM

IMAGES COURTESY BRIAN P. COPPOLA

Student participants Amy Smith (l) and Mike Payne (c) work on the inorganic chemistry challenge under the watchful gaze of an evaluator.

Student participants Jack Watson (l) and Maddie Herman (r) work on the physical chemistry experiments.



Student competitors Qiuhan Li (l) and Dan Reader (r) prepare to start the organic chemistry laboratory exercises.

Professors Chengjian "CJ" Zhu (Nanjing University) and Brian Coppola (University of Michigan).

Student competitors at the NUCLT work with a variety of instrumentation.

explain, "The educational emphasis in China simply seems to be different. Not better, not worse, just different."

"My impression," Payne continues, "is that we focus less on the functional details of process and procedures and more time on design and interpretation. We may do so because we tend to just follow the process steps as written directions, or because the operation may be automated. There were things on that test I've just never thought about, and I find myself wishing I had."

The students from Sheffield (Amy Smith, Jack Watson, and Dan Reader) reflected on the chance for comparison and conversation on how the U.K. system contrasted with both the Chinese and U.S. programs. Smith agreed with Payne that the written examination emphasized aspects of laboratory practice that were not commonplace in their experience. On the other hand, the USUK students were comfortable with their familiarity and experience, covering a breadth of experimental techniques from their education.

Maddie Herman, a UM senior who is heading to the University of Wisconsin-Madison for graduate school, is an organic chemist who was assigned to participate in the physical chemistry experiments. She thought students at her alma mater could learn from what China was doing. "Not only is the laboratory education here clearly more comprehensive, but some of our labs seem quite stale compared with the ones I was working on, and I would like to see these incorporated into our program."

Peking University Professor Lianyun Duan, one of the original architects of the NUCLT, says, "We need to do everything we can to promote excellence in experimental chemistry, because only through doing the best science can we solve some of the world's most vexing problems." iC

Brian P. Coppola *is the Arthur F. Thurnau Professor and associate chair for educational development and practice in the department of chemistry at the University of Michigan–Ann Arbor.*

Graduate School: To Go or Not to Go

BY AMY M. HAMLIN

If you're thinking about becoming a researcher, educator, or pursuing another career requiring significant expertise in chemistry, you are probably thinking about going to graduate school. But grad school is more than just an extension of college. Before embarking on the journey to a master's or Ph.D., there are many differences between college and grad school you may need to consider.

COURSEWORK. As an undergrad, there is a huge focus on grades and GPAs. You are expected to learn from lectures, textbooks, and hands-on laboratory experiments — and then be able to demonstrate your understanding of concepts through exams, projects, or papers. In graduate school, there is less of a focus on classwork and GPAs. You only take classes for the first year or two, which typically move at a faster pace and require more time outside of lecture.

Your focus in graduate classes should not be on the grade, but instead on setting the foundation necessary for further independent study in your field. Progress isn't measured by credit hours or grades, but rather by completing specific program requirements, working in the research lab, and your ability to communicate results to other scientists. Graduate program requirements may include research reports, a qualifying exam, teaching requirements, a research proposal, a written thesis, and a thesis defense. Your research advisor will also have a big influence on your progression through graduate school and when you complete your studies.

As you progress through your graduate career, you will be expected to learn independently through reading the literature and attending seminars instead of reading textbooks and attending formal lectures. After classes are completed, there are no formal lectures or exams encouraging you to learn; instead, you must motivate yourself to continue learning. Reading and searching through the literature will become a part of your daily routine. You will also learn from colleagues and visiting professors, and through group meetings and informal discussions with lab mates.

RESEARCH. Perhaps the greatest difference between undergraduate and graduate school is that as a grad student, research becomes your main priority. If you do research as an undergrad, it is fitted into your schedule around classes, studying, and other extracurricular activities. As a grad student, everything is scheduled around your time in the lab, which can easily be 60-80 hours per week.

Early in your graduate career, you will begin working on your thesis project, and working on this project will be your primary focus for the next few years of your academic life. Research will often require late nights, early mornings, and weekends in the lab. Extracurricular activities and time with family and friends are often scheduled around experiments.

In college, there are times when studying for finals or finishing a project requires your complete attention. This is also true for graduate school. The few weeks before a department presentation or a qualifying exam can be very stressful, but these are the times when the studying and planning skills you learned in college will come in handy.

There may also be occasions when more time is required in the lab, right when you're also trying to finish a paper or thesis, for example. The organizational skills you learn in college will be very useful during semesters in grad school when you have to juggle classes, teaching, and research, so don't throw out that college planner just yet!

GRADUATION. The journey through grad school is unique for each student and is often influenced by your specific research project, as well as your advisor's opinion of your progress as a researcher and teacher. Time to complete a graduate degree depends on the group you join, the research project you undertake, and the pace at which you work. One's journey is also influenced by future career and personal goals. For example, someone who wants an academic career may focus more on teaching and mentoring compared with someone focused on a career in industry.

Graduate school is a serious commitment, but it also provides many new and exciting opportunities to learn and make a contribution to the scientific community. iC

Amy M. Hamlin *was a graduate student at the University of California, Berkeley studying synthetic organic chemistry. She graduated from the University of Detroit Mercy in 2009 with a B.S. in chemistry.*

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Chemical Health & Safety

BY ACS STAFF

Health and safety professionals assist employers in maintaining safe workplaces and managing environmental issues. They look carefully for practices that may cause harm to employees, property, the environment, or the general public, and recommend actions that will reduce the likelihood of such adverse incidents occurring.

There are many specialties within the chemical health and safety field. In industry, these types of people are most often found in an Environmental, Health and Safety (EH&S) department.

Career Path

New health and safety professionals collect data, generally under the supervision of more experienced workers. As their knowledge and expertise increases, they move into more difficult projects with greater independence, which may require an advanced degree. Those who start out in the field with an advanced degree will progress faster.

Employment Trends

This field is predicted to grow at an average of 6% between 2014 and 2024. Increasingly complex regulations and constant changes mean people with up-to-date knowledge are needed, and continuing education is required to remain in this field. While employment is most common in the manufacturing and construction sectors, a growing commitment to safety is encouraging employment of these professionals across all areas.

Is This Career a Good Fit for You?

A career as a health and safety worker requires caring about both people and the environment, and having a passion for making the workplace as safe as possible. If you enjoy solving problems and convincing others to "do the right thing," this could be the career for you. However, you must be prepared for the responsibility — you may be accused of being too strict if nothing goes wrong, but not strict enough should someone get hurt. iC

Quick Facts

OPPORTUNITIES

- EH&S professionals will always be needed to enforce regulations in the workplace and improve conditions for workers.

REQUIRED EDUCATION

- An associate's degree or certificate is typical for a technician, while a bachelor's degree (electrical, chemical, mechanical, industrial, or other engineering disciplines) is generally required for entry as a specialist.

SALARIES SOURCE: BUREAU OF LABOR STATISTICS

- Industrial Health and Safety Technicians — $48,070 (2014)
- Occupational Health and Safety Specialists — $70,210 (2014)
- Industrial Health and Safety Engineers — $84,600 (2014)

Typical work duties

- Inspect machinery, facilities, laboratories, and equipment to identify potential chemical, physical, biological, or radiological hazards
- Collect and analyze samples to monitor workplace occupational exposure levels
- Attend continuing education classes to stay current on changing regulations
- Recommend, develop, and deliver safety training for employees
- Monitor compliance with, and effectiveness of, existing policies and procedures
- Recommend improvements to workplace procedures and employee safety and awareness programs
- Investigate accidents to determine their cause and identify preventative mechanisms

Technical Skills

- Data collection and analysis using computers and sophisticated testing equipment
- Detail-oriented, to make sure everything is collected and reported accurately
- Creativity and problem-solving skills to create safe and productive work environments
- Negotiating skills to get all interested parties to agree on workable solutions
- Physical stamina for plant tours and data collection in all sorts of environments
- Continuous learning, to keep up on changing regulations and advances in ergonomics, biological effects, and more
- Oral and written communication skills to convey findings and recommendation

Chemists in the Real World: Brandon Chance

- **Chemical Safety Program Manager, Princeton University**
- **B.S., Chemistry, Texas Lutheran University, Seguin**
- **M.S., Organic and Polymer Chemistry, Texas A&M University, College Station**

Brandon Chance helps ensure a culture of safety in Princeton University's laboratories. He conducts training on the safe use of chemicals, equipment, and facilities. He monitors hazards and risks. In the event of a chemical spill or laboratory incident, he is one of the primary emergency responders, though a big part of his job is helping researchers avoid incidents in the first place. When researchers set up new equipment, novel experiments, or new procedures, Chance conducts hazard and risk assessments to minimize the potential for damage and injury.

What's a typical day on the job like?

A typical day starts between 8 and 9 a.m., when I start off by catching up with emails and arranging my calendar for the day. If a training session is scheduled, I prepare for that session and review appropriate materials. I could have a variety of meetings scheduled with anyone from undergraduate researchers to the Office of the Dean for Research. At least two days a week, I am out on campus visiting laboratories and catching up with the researchers on current projects, performing audits, or offering my help and expertise wherever it is needed. If there is an incident on campus involving a laboratory, then I am called out immediately to assess and investigate the situation.

My favorite part of the job is the on-campus consulting and outreach I am able to do across a broad spectrum of fields. Researchers contact me with questions regarding procedures and methods and how to safely accomplish various research goals. I work very closely with undergraduates on a variety of student projects. I am also the lead investigator on lab-related accidents that occur on campus.

How did you get your start in your career?

When I graduated with my B.S. degree in chemistry, I had already been accepted to graduate school, but wanted to gain a little work experience first. I worked for one year as a temporary employee for AkzoNobel.

After that year, I enrolled in a Ph.D. program at Texas A&M University (TAMU), with a focus on organic and polymer chemistry. In my third year of graduate school, the Science Program Chair from TAMU's new branch campus in Qatar was visiting on a summer sabbatical and actively recruiting experienced people to set up research and academic labs, as well as teach the laboratory courses. It was over a coffee at the campus library that I made the decision to take a leap of faith, leave graduate school, and move halfway around the world. It was one of the best decisions that I have ever made!

When I made my decision, I had already done enough work in my graduate studies to finish with a master's degree, so I wrapped up my research and wrote my thesis while I was making preparations to move.

What do you like most about your job?

I love the part of my job that gets me out into the laboratories and into the field with the researchers. While part of my job is as a traditional compliance officer, it is the lab and field work that keep me excited.

Coming from an international research background, I can really connect with the students' and faculty members' research projects and keep abreast of the awesome work that is going on at Princeton. My experience in Qatar showed me how other countries approach research and safety issues, and I have a better understanding of what foreign students experience when they come to the United States to study. I was born and raised in the Houston, Texas, area, and Qatar is a desert nation — so coming to Princeton was a real change for me as well.

What's the best career advice you've received?

Never shy away from a challenge, and always look toward the future. Do not lock yourself into one specific field or a specific job. Be flexible and willing to go outside of your comfort zone.

I would advise new graduates to get in as much training and travel as they can early in their careers, in order to learn things about their jobs that they didn't pick up in school. Don't think that you have to go straight into graduate school. Think outside the box — lots of options are available.

What has contributed to your success?

My graduate school experience and research background have been a big help. I approach safety issues more as a collaborator than as an enforcer of rules. I do some background research on faculty members and their projects so that I can approach them as a collaborator. I help them design and conduct their research safely, rather than coming in and imposing limitations on them. iC

Six Ways Research Can Fire Up Your Chapter

BY JUSTIN D. FAIR AND ANNE E. KONDO

Let's say you've just been elected president of your ACS student chapter. Member attendance this past year was lower than in previous years, and you're looking to reinvigorate the chapter. But how? More socials? More outreach? What about more research?!

Educators have long known that research does far more than simply advance the field of chemistry. Getting involved in research helps you build and integrate your chemistry knowledge. You have the chance to develop instrumentation, safety, and critical thinking skills — the types of skills employers look for when hiring.

Most importantly for chapters, research is a great way to engage students in science. But how can a student chapter support research?

Here are six ways your chapter can use chemistry research to fire up its members.

1 Talk about research

Group discussions about research can give members opportunities to reflect on the skills they acquired through their coursework, and how those skills can help them pursue ambitions after college. You can hold these talks at each chapter meeting, once a month, or each semester. They can take place in a classroom, lab, or other low-key setting.

Invite chemistry faculty or chapter members who are doing research to discuss their work in brief talks that leave lots of time for discussion. Invite outside speakers from regional universities or companies to give longer talks. Such keynote speakers are usually pleased to be invited by students and will most likely accept the invitation.

Chapter members who have not started an active research project can also give presentations. Working alone or in pairs, these members can investigate current trends in science and give low-stakes presentations to the chapter.

2 Develop skill-based workshops

Chapter members or faculty involved in research can provide tours of their lab(s). In addition to areas of chemistry, tours can emphasize a lab's scientific techniques, specific instrumentation, or methods of data analysis. After a semester's worth of tours, members can decide which areas and techniques piqued their interest. Then student- or faculty-led workshops can be scheduled.

These workshops could help student members develop a broader and deeper understanding without the need to join multiple labs for undergraduate research. Hands-on, problem-based approaches to the workshops can expose students to modern techniques, instrumentation, and data analysis in realistic settings.

Student member workshops can also focus on foundational, cross-disciplinary skills that all science majors should master. These workshops provide an opportunity for the chapter to involve other student groups. Short events led by upper-level students can focus on freshmen and sophomores practicing basic skills, such as safe handling of hazardous materials, preparing solutions, making dilutions, pipetting, using gel electrophoresis, distilling, and titrating.

Software commonly used in research and data analysis, such as Word, Excel, PowerPoint, ChemDraw, NVivo, and LaTeX can be learned and practiced outside of assignments and classes. Give your chapter members opportunities to learn how to use software packages that challenge their data analysis and communication skills. For example, they could learn to use Word's built-in reference and cross-reference tools before they write their next big paper or undergraduate thesis. Other examples include learning to use the graphing capabilities and analysis toolpack available in Excel and other software programs.

3 Invite alumni to visit

Alumni can bring many opportunities directly to your members, yet are often an untapped resource for an ACS student chapter. Alumni can offer a perspective to help students envision and plan their future careers because they have literally been where you and your fellow members are.

Younger alumni can discuss topics like entering the workforce or graduate school, what areas of chemistry employers are interested in, and how research is conducted in industrial, academic, or government labs. Seasoned alumni can give members a glimpse of how research techniques have changed over the years or what trends have come and gone... and come again.

In addition to offering their perspective on their particular workforce sector, alumni can help chapter members understand the importance of, and how to start, networking. Homecoming is always a great time to bring in alumni. With enough planning, you can also hold alumni panels, where alumni can share their experiences and members can ask questions.

4 Organize a chapter research program

The National Science Foundation's Research Experiences for Undergraduates (REU) program gets lots of attention. But what about students who don't get an REU, or first- or second-year students and chapter members who aren't chemistry majors?

All year, your chapter members have been meeting with students and faculty, learning what type of research they do. Why not see if these labs have any unpaid or even paid positions available? Perhaps there are smaller projects that your less-experienced members can help with during the semester or over the summer.

An ACS student chapter can become the central hub and scientific community for its members. Member events can include time for professional development activities, such as writing résumés and cover letters and presenting research findings. You could even conclude the term with a poster session highlighting members' contributions to science.

5 Recognize active members

Show your appreciation for fellow ACS student members who spend time enriching the chapter. Many chapters have awards such as Student Member of the Year. Your chapter may want to recognize the accomplishments and service that other members bring to an active chapter, such as Active Student Researcher Award, Student Professional Development Award, Student Master of Scientific Techniques, and Student Master of Scientific Instrumentation.

6 Get started on your chapter's future

Chapter leaders, with input from members and the department, have many opportunities to shape the direction of their chapters. Examples include helping to connect members with research and other learning opportunities, as well as hosting events to give members first-hand experience in scientific techniques, tools, and procedures. Other options are organizing activities and projects where members can practice their initiative, work ethic, and skills in communication, teamwork, planning, or leadership.

The bottom line is that one of the most valuable services that your chapter can provide to its members is to provide activities and events that are not only fun but also give members the experiences they will need to stand out from the crowd, wherever their future careers take them. iC

Justin D. Fair *and* **Anne E. Kondo** *are associate professors in the chemistry department at Indiana University of Pennsylvania. Fair has research interests in organolithium methodology, green chemistry, and organic laboratory curriculum. Kondo's research interests are in the effects of molecular and laser parameters on nonlinear laser-molecule interactions.*

SPOTLIGHT

Salt Lake Community College

Salt Lake City, UT

COMPILED BY ROBIN LINDSEY

Chapter president: Deborah West and Sierra Cunningham **Chapter members:** 218 **ACS student members:** 189
Institution description: Large, public, urban, two-year

Q: In what ways does your chapter give back to the community?

A: We organized a fundraiser for the Primary Children's Medical Center's Festival of Trees and raised over $6,000 for their Kids in Need program. We conducted 12 Elemental Expeditions to local elementary schools to get kids excited about chemistry through hands-on demonstrations.

Q: What is your most successful fundraiser to date?

A: Last year we were able to raise all funds needed to attend ACS's spring national meeting by working concessions at Utah Jazz basketball games. The arena gave a matching donation to our funds.

Q: What social events has your chapter organized recently?

A: At the end of spring semester, we hosted a members' retreat to Lava Hot Springs, Idaho. We were able to get away from the stress of school and take part in exciting team-building exercises. We also held a student-faculty-alumni golf tournament last April.

Q: How have your members benefited from attending a recent ACS regional, national, or local section meeting?

A: We recently attended the ACS national meeting in San Diego where our chapter received the ACS Outstanding Award and the Green Chemistry Award. Most of our undergraduate research projects received presentation awards. Being able to attend this conference and win awards inspired all of our members to reach a goal of high achievement this coming semester.

SLCC chapter members at the 2015 ACS Spring National Meeting Undergraduate Poster Session.

Q: How do you ensure a smooth officer transition from year to year?

A: In the spring, we have elections to fill opening positions before the current officers leave to allow for a mentoring period. During the fall semester, we keep in close contact with past officers via email and phone conversations.

Q: What is your most successful recruiting event/method?

A: Our Chemical Information Series (CIS) is, by far, the most effective activity we do for recruitment and retention. The CIS encourages student member participation by conducting activities related to many of the professional careers that our students are pursuing.

Q: What else would you like *inChemistry* readers to know about your chapter?

A: Our biggest strength comes from our dedicated chemistry faculty who are always there to lend a hand, provide encouragement, give directions, and readily support our chapter activities. iC

Faculty advisor:
Ron Valcarce, 23 years

Q: How did you become a faculty advisor?

Valcarce: Having been active myself in an ACS student chapter as an undergraduate, I knew of the opportunities for leadership, camaraderie, education, and service the ACS Undergraduate Programs Office could provide. I wanted our students here at SLCC to have the same experiences.

Q: What has been the most rewarding aspect of your service as a faculty advisor?

Valcarce: I have particularly enjoyed watching new officers gain confidence as they interact and learn to lead the chapter. The skills they learn in these leadership positions help these students make the transition to a four-year institution and ultimately to their chosen profession.

Q: What challenges have you faced in your position?

Valcarce: Because SLCC is a two-year institution, we have a high rate of student membership turnover. Many times students do not join our chapter until their sophomore year, and then have only one year of membership before they move on to a four-year institution. So we have to be very active in recruiting and training new officers on a yearly basis.

Q: What advice can you offer those new to the advisor position?

Valcarce: Let your students run the chapter and make their own decisions. I have always felt that the role of advisor is to help the students get organized, support their dreams, give them direction, keep them out of trouble and then get out of their way. iC

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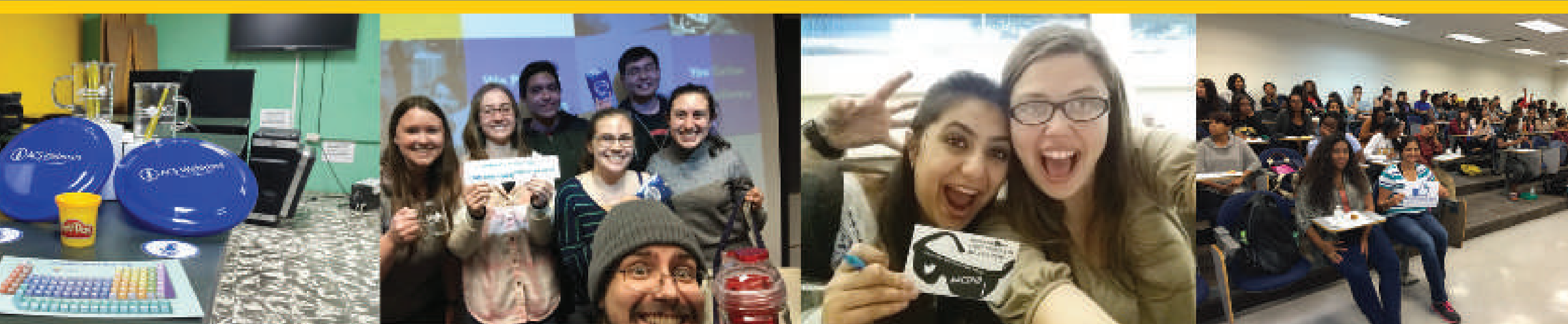

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