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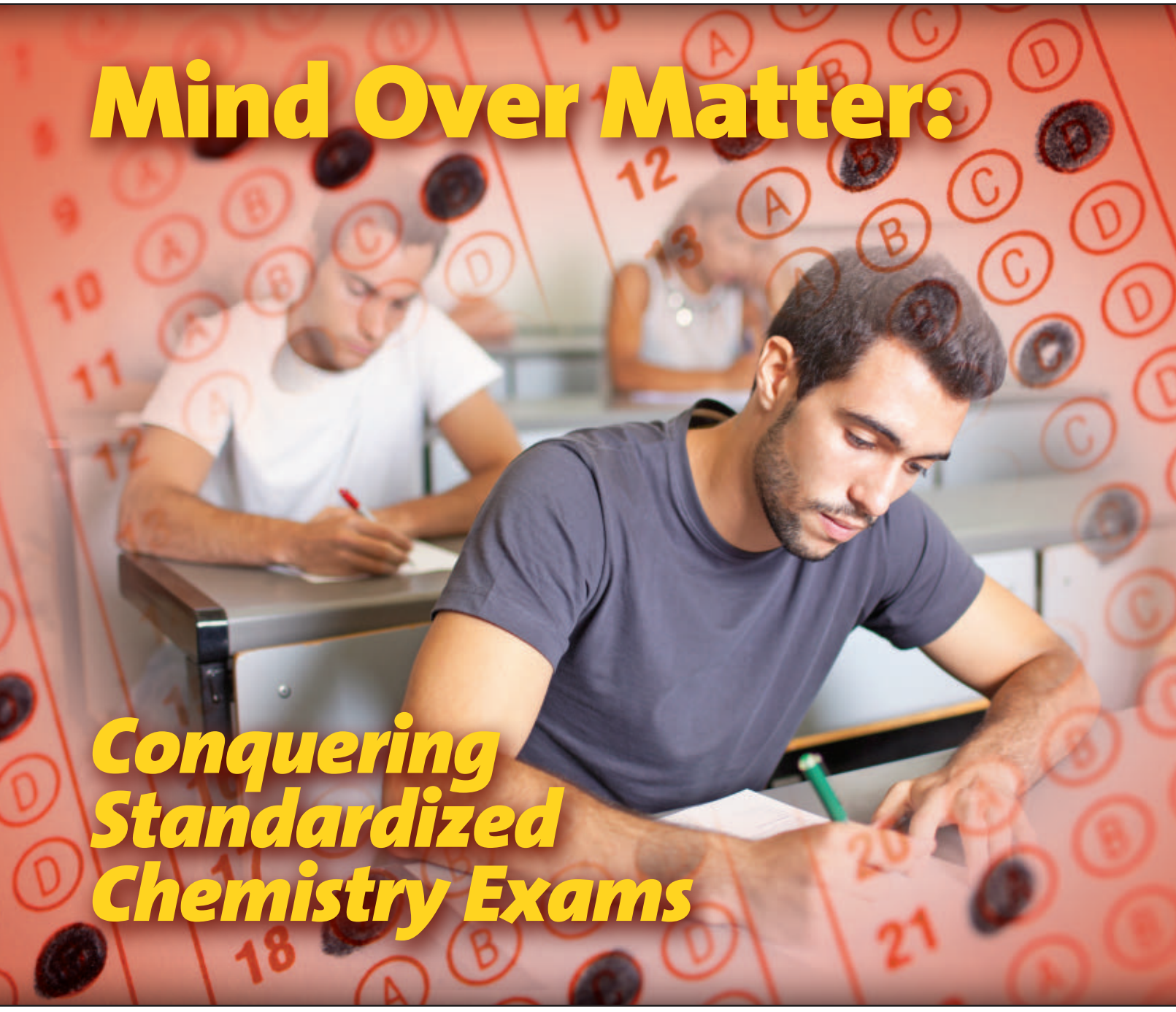
THE MAGAZINE FOR ACS STUDENT MEMBERS September/October 2014



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THE MAGAZINE FOR ACS STUDENT MEMBERS

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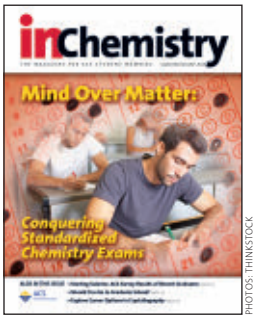

PHOTOS: THINKSTOCK

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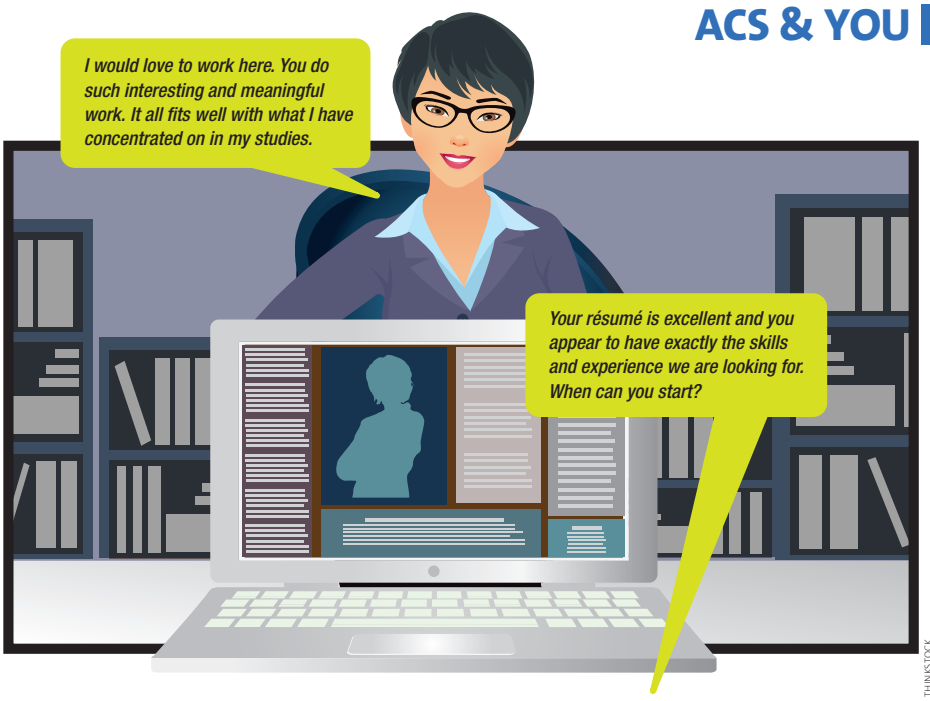
EDITORIAL: Landing That First Job Takes Preparation—*NOW!*

BY LOUISE LAWTER



THINKSTOCK

Each year, ACS conducts a survey of recently graduated chemists and chemical engineers to learn about starting salaries, occupational status, and overall trends. Results from the most recent New Graduates Survey (reprinted on pages 10-12 from the June 22, 2014 issue of *Chemical & Engineering News*) revealed that overall unemployment among new graduates rose from 12.6% in 2012 to 14.9% in 2013. This rise was primarily due to the high unemployment of those with B.S. degrees, who comprised the majority of respondents.

These data suggest that graduates in the next few years will be facing a more competitive environment. Therefore, it is more important than ever to prepare oneself well for the job search process.

Deciding what you want to do is fundamental in any economic environment. Do you enjoy working in the laboratory? Do you enjoy new situations and interaction with people? Would you like to be working in a production facility or taking a chemical process from bench to pilot scale? The more you know about the types of jobs that are available to you as a chemist, the better you can assess which ones you may want to target.

To gain this insight, take advantage of opportunities to meet and talk to chemists about what they do. Attend a meeting of your ACS local section. This is a great way to meet practicing chemists, build your networking skills, and learn of job opportunities. Suggest that your ACS student chapter invite chemists and chemical engineers of different backgrounds to talk about their jobs, or perhaps organize a tour of a company or government lab in your area. For more information and resources your chapter may find helpful, visit **www.acs.org/undergrad**.

Seek out internship opportunities! This is a great way to find out about the types of jobs that exist, and also gain the work skills you will need to succeed. You can also gain valuable work experience to put on your résumé. Many companies offer summer internships for students. Check the websites of local chemical or pharmaceutical companies for career information and available internships. You can also find a list of available opportunities on the ACS Get Experience Database at **www.acs.org/getexperience**.

Another factor to take into consideration as you prepare for your career is the growing globalization of science and business. You can improve your marketability by studying a second language or learning about other cultures via classes, cross-cultural research, or extracurricular activities.

What other ways can you differentiate yourself from other candidates with similar technical knowledge? Increasingly, new jobs are coming from smaller, entrepreneurial companies where employees often fill more than one role. Employers are looking for people who can work well in teams and be flexible, adaptable, and innovative. Candidates who can demonstrate these skills will have an advantage.

What if your "dream job" requires an advanced degree, and you are considering graduate school? In addition to excellent academic credentials, demonstration of research skills will be critical. The best way you can prepare is to gain research experience through summer programs or working with a faculty member part-time during the school year.

The ACS has several tools, including the new College to Career website, that can help you navigate the road to your career and beyond. These resources have been compiled into the newly launched Career Navigator website **www.acs.org/careernavigator**. Look there for information on training courses, advice on job searching, webinars on preparing for graduate school, and much more.

The employment environment may be changing, but one fact remains: there will always be the need for talented chemists and chemical engineers to solve present and future challenges! Pursue your dream! iC

Louise Lawter *is a retired flavor and food ingredient industry R&D executive. She received a B.S. in Chemistry from UMass Dartmouth and did graduate studies in organic chemistry at Boston College. She is currently Chair of the ACS Committee on Economic and Professional Affairs and a councilor and active member of the Princeton Section of the ACS.*

ATOMIC NEWS

COMPILED BY JESSICA ROBERTS

Source: ACS Office of Public Affairs Weekly PressPac, www.acs.org/content/acs/en/pressroom.html

Key chocolate ingredients could **help prevent obesity, diabetes**

Improved thinking. Decreased appetite. Lowered blood pressure. The potential health benefits of dark chocolate keep piling up, and researchers are now coming closer to understanding what ingredients in chocolate might help prevent obesity, as well as type 2 diabetes. They found that one particular type of antioxidant in cocoa prevented laboratory mice from gaining excess weight and lowered their blood sugar levels. The report appears in ACS's *Journal of Agricultural and Food Chemistry*.

Andrew P. Neilson and colleagues explain that cocoa, the basic ingredient of chocolate, is one of the most flavonol-rich foods around. That's good for chocolate lovers because previous research has shown that flavonols in other foods such as grapes and tea can help fight weight gain and type 2 diabetes. But not all flavonols, which are a type of antioxidant, are created equal. Cocoa has several different kinds of these compounds, so Neilson's team decided to tease them apart and test each individually for health benefits.

The researchers fed groups of mice different diets, including high-fat and low-fat diets, and high-fat diets supplemented with different kinds of flavonols. They found that adding one particular set of these compounds, known as oligomeric procyanidins (PCs), to the food made the biggest difference in keeping the mice's weight down if they were on high-fat diets. They also improved glucose tolerance, which could potentially help prevent type 2 diabetes. "Oligomeric PCs appear to possess the greatest antiobesity and antidiabetic bioactivities of the flavonols in cocoa, particularly at the low doses employed for the present study," the researchers state.

Read more about the research: "Oligomeric Cocoa Procyanidins Possess Enhanced Bioactivity Compared to Monomeric and Polymeric Cocoa Procyanidins for Preventing the Development of Obesity, Insulin Resistance, and Impaired Glucose Tolerance during High-Fat Feeding," *J. Agric. Food Chem.,* 2014, 62(10), pp 2216–2227.

Sneaky bacteria change key protein's shape to escape detection

Every once in a while in the United States, bacterial meningitis seems to crop up out of nowhere, claiming a young life. Part of the disease's danger is the ability of the bacteria to evade the body's immune system, but scientists are now figuring out how the pathogen hides in plain sight. Their findings, which could help defeat these bacteria and others like it, appear in the *Journal of the American Chemical Society*.

Linda Columbus and colleagues explain that the bacteria *Neisseria meningitidis*, one cause of meningitis, and its cousin *Neisseria gonorrhoeae*, which is responsible for gonorrhea, enter human cells through the receptor-mediated engulfment triggered by Opa proteins. Gonorrhea can be cured, though one type of the responsible bacteria has reached "superbug" status, becoming resistant to known drugs. If meningitis is not treated immediately with antibiotics, it can cause severe disability and death. In a search for new ways to treat these diseases, researchers are looking more closely at how the bacteria navigate the body undetected. When someone gets an infection, antigens that stud the pathogen's outer layer usually trigger the immune system. But these two kinds of *Neisseria* bacteria can elude the body's defense cells, and Columbus's team wanted to know how.

They combined two approaches to figure out the architecture of one of the bacteria's outer proteins that help it gain entry into human cells. They found that the protein's outer loops interact with each other weakly, causing their structure to constantly change. This shape-shifting makes for a kind of camouflage that hides them from the host's immune responses, at the same time preserving their ability to bind to and enter a person's cells. This deeper understanding could help lead to new treatments for bacterial diseases.

Read more about the research: "Structure of the Neisserial Outer Membrane Protein Opa60: Loop Flexibility Essential to Receptor Recognition and Bacterial Engulfment," *J. Am. Chem. Soc.,* May 9, 2014 (Web).

ALL PHOTOS IN ATOMIC NEWS: THINKSTOCK

Preserving bread longer: A new edible film made with essential oil

Essential oils have boomed in popularity as more people seek out alternatives to replace their synthetic cleaning products, anti-mosquito sprays, and medicines. Now researchers are tapping them as candidates to preserve food in a more consumer-friendly way. A study from ACS's *Journal of Agricultural and Food Chemistry* reports the development of new edible films containing oils from clove and oregano that preserve bread longer than commercial additives.

Nilda de F. F. Soares and colleagues note that the search for new ways to keep packaged food from spoiling has led some to essential oils, which can keep bacteria and mold at bay. Oils from clove and oregano had already been incorporated into edible films, but they had not yet been optimized for effectiveness and tested under real-life conditions for other uses. So Soares's team decided to test how well different edible films with clove and oregano essential oils could maintain bread's freshness and see how they measured up against a commercial antimicrobial agent. Bread is often kept fresh with calcium propionate. Although it occurs naturally, some research suggesting negative side effects has tarnished its popularity.

The scientists bought preservative-free bread and placed slices in plastic bags with or without essential oil-infused edible films. To some slices, they added a commercial preservative containing calcium propionate. After 10 days, the latter additive lost its effectiveness, but the edible films made with nanodroplets of the oils continued to slow mold growth.

Read more about the research: "Edible Films from Methylcellulose and Nanoemulsions of Clove Bud (*Syzygium aromaticum*) and Oregano (*Origanum vulgare*) Essential Oils as Shelf Life Extenders for Sliced Bread," *J. Agric. Food Chem.,* 2014, 62(22), pp. 5214–5219.

A more earth-friendly way to make **bright white cotton fabrics**

With a growing number of consumers demanding more earth-friendly practices from the fashion world, researchers are developing new ways to produce textiles that could help meet rising expectations. They report in the ACS journal *Industrial & Engineering Chemistry Research* one such method that can dramatically reduce the amount of energy it takes to bleach cotton while improving the quality of the popular material.

Quan Zu and colleagues point out that the cotton industry's current whitening techniques require bleaching the natural fiber at very high temperatures with hydrogen peroxide. Although this method results in the bright white material consumers have grown so fond of, it also lowers the quality of the material and takes a lot of energy to carry out. Multiply that by the 7.3 billion pounds of cotton produced each year in the United States alone, and the energy needs soar. To cut down on the energy the textile industry uses to bleach cotton, Zu's team targeted its efforts toward lowering the bleaching technique's high temperatures.

They developed a novel compound based on amino nitriles that, when used with hydrogen peroxide, decreases the bleaching temperature from 200 degrees Fahrenheit to 140 degrees Fahrenheit. The authors estimated that 60-degree difference would result in a process requiring less than half the energy of the commercial technique. It also produced less wastewater, improved the weight of the material, and performed its original function — whitening the cotton. Since many materials destined to become clothing eventually take on various hues, the scientists also tested dyes and found the cotton bleached at the lower temperature could be made just as vibrant as its high-heat counterpart. They successfully showed the treatment's effectiveness on knitted cotton fabric in commercial-scale trials.

Read more about the research: "A Novel Low Temperature Approach for Simultaneous Scouring and Bleaching of Knitted Cotton Fabric at 60°C," *Ind. Eng. Chem. Res.,* May 17, 2014 (Web).

96% ***The total energy saved when recycling an aluminum can versus fabricating a new can from raw bauxite.***

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To see detailed information and apply, visit www.acs.org/sci

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http://maps.acs.org

ABSTRACT DEADLINE: MONDAY, NOVEMBER 3, 2014

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"Speaking Simply and Communicating Your Science"

Register Now for This FREE Program-in-a-Box Webinar on October 7, 2014

BY TANYA Y. FOGG

It's the start of a new academic year... and ACS is at your side with new opportunities for you and your student chapter. Each issue of *inChemistry* will introduce you to ACS programs and services that offer learning and professional development opportunities for individual student members as well as chapters. In this issue, we take a closer look at the ACS Webinars Program-in-a-Box, a program sponsored by the ACS Younger Chemists Committee (YCC).

Are you looking for a new and interesting event idea for your student chapter? Want to connect with other chemists? ACS Webinars has a solution!

On Tuesday, October 7, 2014, from 7:00–8:00 p.m. EST, ACS Webinars will be hosting its latest Program-in-a-Box webinar, and your chapter is invited to attend. Sponsored by the ACS YCC, the webinar is titled "Speaking Simply and Communicating Your Science." ACS provides the speaker and materials. You gather the crowd. It's as simple as that!

How it works

This Program-in-a-Box event provides an easy, inexpensive way for your student chapter to connect with others, including your ACS local section and other students in your area. In addition, you can use the event to provide valuable networking opportunities and energize your student chapter for another year of fun and valuable meaningful activities. ACS Webinars conducts the webinar program and provides all of the materials free of charge. Best of all, each participating student chapter is only responsible for finding a physical location for presenting the webinar to audience members and distributing the supplied materials to participants.

We provide the program – you provide the audience!

Your chapter is invited to host the Program-in-a-Box webinar "Speaking Simply and Communicating Your Science" on Tuesday, October 7, 2014, from 7:00–8:00 p.m. EST. Gather your friends, choose a location, and register for the event.

ACS MAKES HOSTING THIS EVENT SUPER-EASY BY PROVIDING:

- Flyers to promote online and on-site
- Icebreaker activities
- Interactive demonstrations
- Fun discussion topics to promote networking
- Access to live Q&A with industry experts
- Prizes to raffle
- Career resources
- And more!

Don't miss the next big event. Register now! https://bitly.com/acswebinarspib

WHAT ACS STUDENT CHAPTERS ARE SAYING ABOUT PROGRAM-IN-A-BOX:

"The program opened my mind to the idea of possible careers."

— CAMERON UNIVERSITY

"One of the most beneficial events our chapter has done."

— UNIVERSITY OF MICHIGAN, FLINT

"Being able to ask questions and hear what other groups are thinking was interesting."

— UNIVERSITY OF MASSACHUSETTS, BOSTON

Why host this event?

As you gather your group and tune in to the "Speaking Simply and Communicating Your Science" webinar event, you and your fellow chapter members will learn how to improve your communication skills. With these newfound skills, you'll be able to give more articulate presentations, and also interview and network more effectively.

In addition, because the webinar is provided online, your chapter will be exchanging ideas with other students and chemistry professionals from around the world during the live Q&A with subject matter experts.

By hosting an event, your student members can gain leadership skills, explore nontraditional chemistry careers, network with fellow students (face-to-face and online), and reap a wealth of extra knowledge during the live Q&A session.

For maximum flexibility, you have the freedom to customize the event by including activities that interest your group, such as offering games, trivia, raffles, and food. Audience sizes can range from just two people to hundreds. Groups meet in a variety of locations, including restaurants, classrooms, and even dorm rooms.

Invite the community!

The Program-in-a-Box is open to student chapters and local sections. Consider making the program a community outreach event by inviting participants from your local community, including high school chemistry students, science teachers, retired chemists, and the general public. This is a great opportunity to bring your community together, on one night, at one time, to interact with others locally and globally. Participants will connect with scientists and share and learn from each other's experiences. Then share photos on your chapter's social media site and ACS Webinars site.

Make your plans now to hold an event. Register to participate in a webinar at **https://bitly.com/acswebinarspib**.

SINCE 2012, PROGRAM-IN-A-BOX PARTICIPANTS HAVE REPRESENTED:

390	33	11
ACS local sections and student chapters	States and territories within the United States	Countries outside the United States

Tanya Y. Fogg *is project manager for the weekly ACS Webinars productions and special events, and she also coordinates the Program-in-a-Box events, which are a collaboration with the ACS YCC.*

The Program-in-a-Box includes raffle prizes, such as this very popular ACS Webinars beaker mug.

Starting Salaries

ACS Survey of 2013 Graduates Finds Higher Unemployment Rate, Little Change in Entry-Level Salaries for Those Finding Work

BY SUSAN R. MORRISSEY

REPRINTED FROM *CHEMICAL & ENGINEERING NEWS*, JUNE 2, 2014, VOLUME 92, ISSUE 22, PP. 28-30.

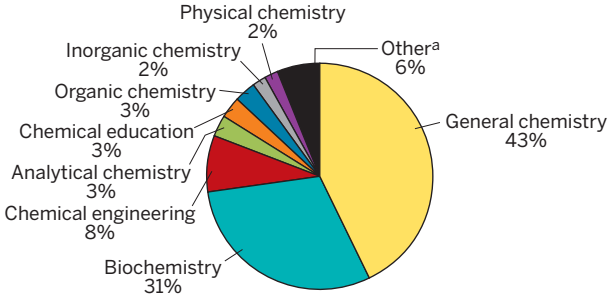
Percentage of respondents who were unemployed job seekers in 2013:

14.9

Percentage of respondents who are female:

51.2

Most respondents' highest degree was in general chemistry or biochemistry.



Respondents = 2,035

NOTE: Of the respondents who indicated both their highest degree earned and their field of highest degree, 85% earned new bachelor's degrees, 5% earned master's degrees, and 9% earned Ph.D.s. **a** Includes respondents who selected agricultural/food chemistry, environmental chemistry, forensic chemistry, materials science, medical/pharmaceutical chemistry, or polymer chemistry as field of highest degree, as well as those who opted not to select a field.

NOTE: For some respondent groups, the number of responses was small and not necessarily representative of the wider pool of chemistry graduates in a given group.

Median 2013 starting salary for inexperienced grads:

$39,560
for bachelor's

$55,000
for master's

$75,750
for Ph.D.s

Median age of 2013 survey takers:

23	**27**	**29**
for bachelor's	for master's	for Ph.D.s

Students who completed their studies and tried to enter the workforce in 2013 experienced a very high unemployment rate of 14.9% — up from 12.6% in 2012, and more than 4 times the 3.5% unemployment rate experienced by all ACS-member chemists in March 2013. The jump in unemployment is primarily driven by a large number of bachelor's degree earners who were unable to find jobs.

At the same time, the percentage of newly minted graduates who found full-time positions was up nearly three points from the prior year to 29.0%. The median starting salary for inexperienced individuals finding full-time jobs remained flat in current dollars at $41,600.

These are some of the key findings of the American Chemical Society's survey of individuals who graduated during the 2013 academic year with degrees in chemistry and related fields. The survey, which was sent to 11,454 recent graduates in October 2013, is conducted annually by Gareth S. Edwards of the ACS Department of Research & Brand Strategy under the guidance of the ACS Committee on Economic & Professional Affairs. A total of 2,035 usable responses were received for an overall response rate of 17.8%. The respondents can be divided into several categories — degree or experience level, for instance, or field of study, gender, or type of employment. For some of these groups, the number of responses was small and not necessarily representative of the wider pool of chemistry graduates in a given group.

BACHELOR'S SALARIES BY EMPLOYER SIZE

Median pay scaled with size of firm

SIZE OF EMPLOYER	MEDIAN SALARY ($ THOUSANDS)
Fewer than 50 employees	$31.1
50–99	32.9
100–499	36.0
500–2,499	40.0
2,500–9,999	45.0
10,000–24,999	41.0
25,000 or more	49.0

NOTE: Median salaries of responding 2013 bachelor's degree graduates with full-time permanent employment.

Responding graduates' field of study varied by degree earned. For bachelor's degree recipients, nearly half earned a degree in general chemistry, a third in biochemistry, and almost 8% in chemical engineering. At the master's level, the top three degree areas were general chemistry (24.8%), biochemistry (16.5%), and analytical chemistry (11.9%). The top areas for new Ph.D.s. were organic chemistry (18.5%), analytical chemistry (16.8%), and chemical engineering and biochemistry (both 13.6%).

STARTING SALARIES OF INEXPERIENCED GRADS

Constant-dollar salaries for M.S. degree earners grew in 2013 but declined for Ph.D. and bachelor's degree earners

	B.A./B.S.		M.S.		PH.D.	
$ THOUSANDS	CURRENT	CONSTANT	CURRENT	CONSTANT	CURRENT	CONSTANT
2005	$37.0	$37.0	$52.0	$52.0	$75.0	$75.0
2006	38.0	36.8	48.8	47.3	66.5	64.4
2007	40.2	37.9	52.0	49.0	77.0	72.5
2008	40.0	36.3	52.0	47.2	80.0	72.6
2009	38.0	34.6	60.0	54.6	76.3	69.4
2010	40.0	35.8	45.0	40.3	75.0	67.2
2011	40.0	34.7	46.7	40.6	85.0	73.8
2012	40.0	34.0	48.0	40.8	80.0	68.1
2013	39.6	33.2	55.0	46.1	75.8	63.5

NOTE: Median annual salaries of responding new graduates with full-time permanent employment and less than 12 months of technical work experience prior to graduation. Constant dollars are 2005 dollars and are calculated using the Consumer Price Index.

SALARIES BY PRIMARY WORK FUNCTION

Salaries for women were higher than those for men in some job areas

$ THOUSANDS	MEN	WOMEN	ALL
Development/design	$60.0	$63.0	$62.0
Management	45.0	34.5	45.0
Professional services	60.0	51.0	56.0
Research	43.8	41.5	42.0
Production/quality control	37.2	40.5	40.0
Teaching	44.5	38.0	40.0
Other	35.0	37.0	36.0
ALL	**$45.0**	**$40.8**	**$43.0**

NOTE: Median salaries for responding 2013 bachelor's degree graduates with full-time permanent employment.

CHEMISTS VS. CHEMICAL ENGINEERS

Chemical engineering grads were more likely to go into industry and were better paid than chemists

	B.A./B.S.		M.S.		PH.D.	
	CHEMISTS	CHEMICAL ENGINEERS	CHEMISTS	CHEMICAL ENGINEERS	CHEMISTS	CHEMICAL ENGINEERS
BY EMPLOYMENT						
Full-time	34%	66%	48%	46%	45%	52%
Part-time	9	2	13	18	6	4
Further study	37	13	19	27	41	44
Unemployed	20	19	20	9	7	0
Seeking	16	19	17	9	7	0
Not seeking	4	0	3	0	0	0
BY EMPLOYER						
Academia	39	16	46	38	49	35
Industry	53	82	46	50	43	57
Government	7	2	8	13	8	4
Self-employed	2	0	0	0	0	4
BY GENDER						
Women	54	38	48	50	45	32
BY CITIZENSHIP						
Temporary visas	2	2	13	30	23	24
SALARIES ($ thousands)						
Full-time permanent	$35.9	$66.7	$52.5	$78.0	$66.0	$90.5

NOTE: Median salary data for all responding 2013 graduates regardless of experience. Numbers may not sum to subtotals or total 100% because of rounding. Table contains some data derived from sample sizes too small to generalize.

WHERE THE JOBS ARE

More respondents found employment in academia than in other sectors

	B.A./B.S.	M.S.	PH.D.
Academia	37%	44%	47%
Chemical industry	30	35	24
Other nonmanufacturing	25	12	21
Government	7	9	8
Self-employed	2	0	1

NOTE: Percentages are for all responding 2013 graduates with full- or part-time employment. Numbers may not sum to 100% because of rounding. Table contains some data derived from sample sizes too small to generalize.

Of the responding bachelor's degree recipients, 36.6% reported finding full-time positions. Those earning master's degrees and Ph.D.s. had more success, with 48.1% and 46.1%, respectively, of respondents saying they had obtained a full-time job. On the other side of the coin, 15.8% of bachelor's degree earners, 16.0% of master's degree earners, and 6.1% of Ph.D. recipients were seeking, but unable to find, employment. This unemployment rate is up from 2012 levels for bachelor's and master's degree earners but down slightly from 2012 for Ph.D. recipients (*Chemical & Engineering News*, April 22, 2013, page 47).

Most of those who did find jobs ended up working in industry. Some 55.2% of bachelor's degree, 46.9% of master's degree, and 45.0% of Ph.D. recipients reported finding full- or part-time work in industry. Academia provided jobs for 36.6% of bachelor's, 44.4% of master's, and 46.7% of Ph.D.s. Finding government jobs were 6.6% of bachelor's degree recipients, 8.6% of master's degree recipients, and 7.7% of Ph.D.s.

For newly minted and employed graduates with less than 12 months of experience, the median starting salary was down from 2012 for earners of bachelor's degrees and Ph.D.s. Specifically for 2013 graduates with bachelor's, the median salary was $39,560 in 2013, down slightly from $40,000 in 2012. For Ph.D.s. the median salary was $75,750, down from $80,000 in 2012.

But the situation was different for master's degree earners. The median starting salary for inexperienced graduates in this group was $55,000, up from $48,000 in 2012.

Those holding chemical engineering degrees reported higher pay. The median 2013 starting salary of Ph.D. chemical engineers was $90,500 as compared with the $66,000 salary reported by Ph.D. chemists. And for those who earned a bachelor's degree, the median salary was $66,700 for chemical engineers, almost twice the $35,900 earned by chemists in this group. There were insufficient data for chemical engineers earning master's degrees.

Median starting salaries also varied depending on sector. For all bachelor's degree respondents with less than 12 months of

ADVANCED STUDIES BY TOPIC

Most chemically trained bachelor's grads continued studies in a field other than chemistry

FIELD OF FURTHER STUDY	B.A./B.S.
Chemistry	**35%**
Other sciences	**27**
Pharmacology	10
Biochemistry	10
Life sciences	4
Other/math	3
Engineering	**4**
Chemical/biochemical	3
Other	1
Health	**30**
Medicine	26
Dentistry	5
Other[a]	**4**

NOTE: Percentages are of respondents who were continuing advanced studies full-time after earning a bachelor's degree in a chemical field in 2013. Numbers may not sum to subtotals or total 100% because of rounding. **a** Includes business management, education, and law.

experience who took a job in the academic sector, the median salary in 2013 was $34,000. This figure is down $2,000 from the previous year. For those who took a job in industry, the median salary was $40,000, the same as it was in 2012. But for those who ended up with jobs in the government, median salaries were up by $1,500 from 2012 to $40,000 in 2013.

Still, for full-time employed graduates with less than 12 months of experience, the 2013 survey shows that the gender pay gap is narrowing. The median starting salary for men in this category was $44,000; it was $40,000 for their female counterparts. This $4,000 gender gap is down from $6,000 in 2012 and $8,000 in 2011.

In general, survey respondents who reported taking a full-time position said they were satisfied, although the degree of job satisfaction varied with advanced degree level. For example, when it comes to feeling professionally challenged by their position, only 69.2% of bachelor's degree recipients indicated they were, whereas 80.3% of master's degree holders and 87.6% of Ph.D.s said the same.

Similarly, when it comes to feeling like their education relates to the field they work in, 74.8% of bachelor's degree earners agreed, compared with 86.6% of master's earners and 93.5% of Ph.D. holders. And when asked if their training and education is commensurate with their job, 70.5% of bachelor's degree earners and 78.0% of master's earners agreed, as compared with 90.6% of Ph.D. holders. More than half of Ph.D. earners — 58.0% — said that the position they accepted is what they expected to be doing when they began their doctoral studies.

Landing a job remained challenging in 2013, and respondents continued to look to a mix of sources for help finding openings. More than a quarter of all respondents said electronic media was the most effective job search method. The most popular electronic job search methods included Internet searches, employee websites, and job-posting sites such as Monster.com, CareerBuilder, Indeed.com, LinkedIn, and craigslist. Other common job-finding methods included faculty advisor help, informal channels, and placement services.

But not all survey respondents opted to join the workforce. Slightly more than a third of them opted to pursue advanced studies or postdoctoral positions. For newly minted Ph.D.s, 41.7% indicated they were taking a postdoc position. This is roughly flat from 2012.

Of respondents graduating with bachelor's degrees, 35.1% opted to continue their studies. More than 35% of this group reported pursuing advanced studies in chemistry, while 25.8% were going on to study medicine and 10.3% to study pharmacy or pharmacology. Of the survey respondents who received a master's degree, 19.8% were pursuing advanced studies, with 61.9% of this group continuing with chemistry studies.

EMPLOYMENT STATUS

Nearly half of Ph.D. and master's degree earners and slightly more than one-third of bachelor's grads were employed full-time last year

& MORE ONLINE To view an interactive graphic comprising these data, visit http://cenm.ag/salsurvey.

	2005	2006	2007	2008	2009	2010	2011	2012	2013
BACHELOR'S									
Full-time	**40%**	**42%**	**43%**	**40%**	**32%**	**33%**	**33%**	**34%**	**37%**
Permanent	31	34	33	31	23	24	23	24	27
Temporary	9	9	10	9	9	9	10	10	10
Part-time	**4**	**4**	**7**	**5**	**7**	**6**	**8**	**9**	**9**
Permanent	1	1	1	1	2	2	2	2	2
Temporary	3	4	5	4	5	5	6	7	7
Graduate/ professional school	**44**	**44**	**40**	**41**	**46**	**46**	**41**	**39**	**35**
Not employed	**12**	**10**	**11**	**14**	**15**	**15**	**17**	**18**	**20**
Seeking	8	6	8	10	12	12	14	13	16
Not seeking	4	4	3	4	3	4	4	4	4
MASTER'S									
Full-time	**50**	**52**	**54**	**49**	**43**	**47**	**48**	**50**	**48**
Permanent	45	44	48	41	38	37	38	44	40
Temporary	5	8	7	7	5	10	10	6	9
Part-time	**9**	**5**	**6**	**6**	**8**	**7**	**7**	**7**	**13**
Permanent	2	0	1	1	5	4	3	2	1
Temporary	8	4	4	5	3	4	4	4	12
Graduate/ professional school	**30**	**34**	**34**	**35**	**30**	**31**	**22**	**32**	**20**
Not employed	**11**	**9**	**6**	**10**	**18**	**15**	**23**	**11**	**19**
Seeking	8	6	3	7	15	11	18	10	16
Not seeking	3	4	3	3	3	4	5	2	3
PH.D.									
Full-time	**44**	**41**	**50**	**53**	**45**	**44**	**38**	**46**	**46**
Permanent	39	37	46	51	40	38	33	41	42
Temporary	5	4	3	3	5	7	5	6	4
Part-time	**2**	**2**	**2**	**2**	**3**	**2**	**4**	**5**	**6**
Permanent	0	1	1	1	0	0	0	1	1
Temporary	2	1	2	2	3	1	4	4	6
Postdoc	**45**	**49**	**41**	**37**	**44**	**45**	**47**	**41**	**42**
Not employed	**9**	**8**	**7**	**7**	**9**	**9**	**12**	**8**	**6**
Seeking	6	6	5	4	7	6	9	8	6
Not seeking	3	2	2	3	2	3	3	1	0

NOTE: Employment status of all respondents as of October each year. Respondents listed by highest degree received. Numbers may not sum to subtotals or total 100% because of rounding. Table contains some data derived from sample sizes too small to generalize.

Susan R. Morrissey *is the assistant director for Science Communications in ACS's Office of Public Affairs. Prior to this position, she was the managing editor for government and policy at* C&EN.

Mind over Matter

Tips for Conquering Standardized Exams

BY MICHELLE BOUCHER

PHOTO: THINKSTOCK

Whether you're preparing for graduate or professional school or taking the ACS standardized subject tests as finals for your courses, chances are that multiple-choice exams loom in your future. Many times students convince themselves that, while they are generally good test takers, they are "horrible at multiple-choice exams." Not true!

If you've had difficulty taking multiple-choice tests, often it may be simple fear or anxiety about the testing format itself that is getting in your way. If you can answer a question on a written exam, there is no reason you can't answer the same question in multiple-choice format... honestly! What may be holding you back from doing your best might be simply the lack of a viable strategy for using multiple choices to your advantage (after all, the correct answer *is* there!) and feeling overwhelmed by the test format.

In this article I've included some practical, proven tips on how to prepare for subject-specific multiple-choice exams. I recommend that you also read "How to Ace Your Chemistry Exams," an article that appeared in the November/December 2011 *inChemistry* (pages 8–10). To access the article, go to **www.acs.org/inChemistry** and click the "Archives" link. That article provides a wealth of information for preparing for all tests, regardless of format.

Before the test

Start early with your review book. Each spring I give my students the standardized ACS Organic Chemistry exam for their final exam, and I always make it a point to alert students about this months in advance, at the start of the fall semester.

Typically, when I see students carrying around the ACS student study guide or a Medical College Admission Test (MCAT) book throughout the school year, I know that those students are more likely than others to do very well in my course. The review guide (like the MCAT review book) isn't intended for studying just for the week before the exam; it can and should be used as a supplement to your class textbook on a regular basis. When you cover a subject in class, you can refer to your review book to see how it is presented (and evaluated) for your standardized exam. Not only will you be preparing for your future multiple-choice exam, you will also be reinforcing concepts that will help you in your course.

Practice creating your own multiple-choice questions. Multiple-choice questions don't simply appear from thin air; people write them. So *you* can write them, too. Spending some time making up multiple-choice questions will demystify them (see below for an example of how to create a multiple-choice question). Also, take some time to think about common mistakes

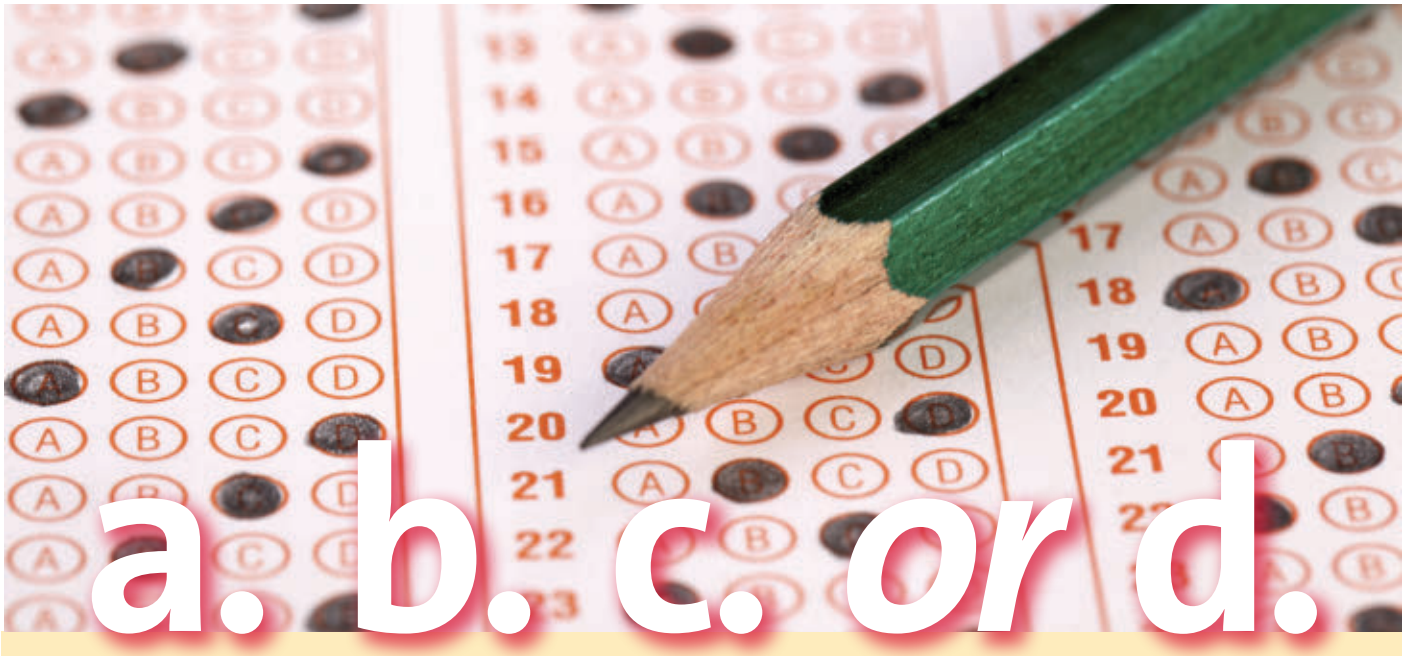


PHOTO: THINKSTOCK

Breaking down a multiple-choice question

Looking for an effective study technique? Try developing some multiple-choice questions. One method is to rearrange a short-answer question to make it into a multiple-choice question. Many multiple-choice questions follow the same format: one correct answer, one incorrect answer with an obvious mistake, and two incorrect answers with common but perhaps less obvious mistakes.

Thinking through common mistakes helps stop you from making those mistakes yourself! For example, the following short-answer question could easily be worked into a multiple-choice question:

A STUDENT DESIGNS A REACTION BETWEEN 1-CHLOROBUTANE AND SODIUM METHOXIDE IN DMSO. WHAT SHOULD SHE EXPECT THE OBSERVED RATE EQUATION TO BE?

This question is testing your knowledge of reactions between primary alkyl halides (like 1-chlorobutane) and strong nucleophiles (like the methoxide ion) in polar aprotic solvents (like DMSO), which favor the S_N2 mechanism. The rate of an S_N2 mechanism is dependent on both the nucleophile and the substrate, so Rate = *k*[1-chlorobutane][sodium methoxide] is the correct answer.

What are some common mistakes students make when answering this question? Some students might wrongly imagine that the reaction was S_N1, where the rate would be dependent only on the substrate, with Rate = *k*[1-chlorobutane]. Others who are confused about substitution rate equations might mistakenly believe that the rate was dependent only on the nucleophile, with Rate = *k*[sodium methoxide]. A third misconception (and the one with the most obvious mistake) would be to imagine that the solvent had a role in the rate equation, something like Rate = *k*[1-chlorobutane][DMSO].

By spotting the false leads and assumptions in answers (a), (b), and (d), you can end up deducing that (c) is the correct answer.

a. Rate = *k*[sodium methoxide]

b. Rate = *k*[1-chlorobutane]

c. Rate = *k*[1-chlorobutane][sodium methoxide]

d. Rate = *k*[1-chlorobutane][DMSO]

Setting up questions like this one for friends, and having them do the same for you, not only allows you to prepare for those standardized exams, but also helps you succeed in the course. iC

or misconceptions surrounding a concept; this is what instructors do when they create incorrect choices for multiple-choice exams. The exercise will help you to understand the material better and avoid common pitfalls.

Take a practice test mimicking test conditions. Most standardized exams have review guides with practice exams. It helps not only to take those exams, but to take them in conditions similar to the conditions you will see on test day. Give yourself a quiet place without distractions, and also without the comforts of your dorm room (snacks, music, comfy chair). A library cubicle, small unoccupied computer lab, or a dedicated testing/study room would be perfect for taking most practice exams. If your exam will be administered on a computer, find out if your career services office or chemistry department has practice tests online so that you can practice on a computer.

Sometimes timing is a huge issue; either students rush through the exam, thinking that they will run out of time, or suddenly they discover that there are only 10 minutes left and still 20 questions to go! If you practice often enough, you won't be caught unawares by the clock or conditions on your exam day.

Set the stage right for the big day. A good night's sleep will do more for your performance on exam day than cramming into the wee hours to learn one last equation or concept. Put down the books by dinner, relax, and get to bed early. The chance that the one last concept you stayed up all night to master will actually be on the exam is small, but it is 100% certain that you will need to be alert and at the top of your game to do your best. Nerves can get in the way with multiple-choice exams differently than with other types of exams. When the answers are already provided, it is easy to second-guess yourself, get confused with all the choices, or even make mistakes in reading the question. Lack of sleep will only make it harder to stay focused. If you need to travel to your exam, be sure to leave yourself lots of time to get to the testing site so that you can relax in the building well before you have to take the test.

During the test

Read the question carefully. Don't be so worried about getting to the next question that you miss something easy because you misread a sentence. Favorite question phrasings include "all of the following *except*..." and "which of the following *does*" or "does *not*." Small details (including use of the words "except," "does," and "does not") make a big difference in the meaning of a test question!

If possible and reasonable, determine the answer to a question before you look at the provided answer choices. Typically a test will include some questions where the answer is fairly obvious and you simply need to look at the answer choices to solve the question. These sorts of questions tend to contain the phrases "which of the following..." or "all of the following except..." Some problems expect you to estimate the magnitude of the answer, rather than do all the arithmetic, and then pick the answer with the correct order of magnitude. But if the question is straightforward and you are comfortable working through the problem, then work through it. You are less likely to be caught up in an easy mistake if you are able to approach the choices having an answer confidently in mind.

Look at the answers carefully. This is the most common problem I encounter when I help students prepare for exams. Be sure to read *all* the answers — even when you are sure that the first answer is correct. If you sometimes tend to skim through the answers, then force yourself to read all the answers carefully. So many students get caught in the trap of missing "choice D: both A *and* C" or another such combination. Consider all the answers before you commit to the one you think is correct. Look carefully at all the choices to see if any answers change your understanding of the problem before you choose an answer to the question. Sometimes you can spot a nuance and avoid choosing an obviously incorrect choice when you examine all of the other possible answers.

Think logically about the provided answer choices if you don't know how to answer the question. If you don't have any clear idea how to solve a problem, look at the answers and see if they spark any ideas. Do most of the answers seem to be reduction products? Then perhaps that reagent you don't remember is a reducing agent. Are the units of most of the answers in grams? Then perhaps the problem is asking you to solve for a mass. Drawing conclusions from the types of answers is a great way to jog your memory as to what the question is really about. Sometimes you can look at answers and easily eliminate one or two of the answers; for example, you know you are solving for moles and one of the answers has kilograms as a unit. If you can narrow the choices down to two possibilities, it is worth taking a guess and choosing an answer, even if you aren't completely certain. Another technique is to work backwards from the answer and see if you can make any of them match the question. If you can connect one of the answers to the question, and solve the problem that way, it doesn't matter if you got there back-to-front!

When in doubt, trust yourself. Some students are often so afraid of trusting themselves to find the correct answer that they are overwhelmed by all of the choices. Trust yourself! If you could produce the answer on a blank page, you can recognize it when it is hidden. If you believe you have the correct answer, don't overthink it, just answer the question and move on. If you are caught between two answers, and you have a hunch that one is correct, don't second-guess yourself — instead, go with your gut. Keep remembering that this is just another test; if you know the material, you can show that you know the material, no matter what the format of the exam. Good luck! iC

Michelle Boucher *is an associate professor of chemistry at Utica College. Between administering the ACS Organic Chemistry exam as a final in her course and serving as a mentor on the Utica College Pre-Health Professionals Committee, she helps many students to prepare for standardized exams every year.*

Should You Go to Graduate School?

BY NANCY McGUIRE

THINKSTOCK

You're getting your bachelor's sometime in the next year or two, the job market still looks bleak, and all the ads for jobs you're interested in feature the words "Ph.D. and three years of experience." You thought you could hang up the book bag after you got your diploma, but now you're wondering if that B.S. degree is going to be enough. Should you start looking at graduate schools?

Motivating factors

First, let's look at some of the reasons that graduate school might make sense. If you've decided that basic research or a faculty position at a four-year college or university is in your future, then a graduate degree — specifically, a Ph.D. from a respected university — is pretty much a requirement. If you love to learn, and you want to explore your field more deeply than you could in undergraduate school, that too is a fairly strong argument for going to graduate school. You might want to explore a master's program, if you're not sure you want to go for the Ph.D. If you're fairly certain about the field you want to enter, and your research shows that a graduate degree will open up specific opportunities, that's a good reason, too. Perhaps a Professional Science Master's degree or a postgraduate certificate program could work for you.

If you're getting your bachelor's degree from a small school in a geographical area dominated by large, well-known universities, getting noticed in a competitive job market could be difficult. You could complete a graduate degree program as a way of building up your credentials — or you could look for work in a less competitive part of the country.

If you're looking for a place to ride out the bad job market, or if you have no idea what you want to do, career-wise, getting into graduate school right now could be a costly sidetrack. Signing up for an internship or taking that job in your uncle's bakery might be just what you need to give yourself time to gather your thoughts and earn some money. Often, just stepping away from the books for a while and experiencing the workaday world is enough to start bringing your longer-term career goals into focus — or show you what you *don't* want to be doing for the rest of your career.

Let's say that you've cleared those hurdles, and grad school is looking pretty good to you. What kinds of practical things should you consider to make this a reality?

Preparing to take the plunge

Although graduate programs share the same campuses, faculty members, and major fields with their undergraduate counterparts, in many ways, you'll be stepping into a different world. Graduate students are older, and in many cases, they have been out of school for a while and are returning to academia with better-defined goals and a sharper sense of purpose than their undergraduate counterparts. Grad students can party, play sports, and pursue hobbies with the best of them, but they are less likely to be in school because their parents required it or because they have nowhere better to be. They are more likely to be funding their own education, and they are willing to put in the long hours and extra effort that a graduate degree requires.

Before you sign on with a graduate program, take a careful look at the time and money that this endeavor will require. Grad students in engineering and the physical and life sciences usually have access to teaching and research assistantships that cover a significant part of tuition and living expenses. Universities also offer student services, from walk-in clinics to on-campus housing, at a nominal cost. On the other hand, textbooks tend to be more expensive at the graduate level,

DOING YOUR RESEARCH

Industry sectors, educational requirements, and typical income

- **U.S. BUREAU OF LABOR STATISTICS OCCUPATIONAL OUTLOOK HANDBOOK**
  www.bls.gov/ooh/a-z-index.htm

Chemistry-specific employment and income statistics

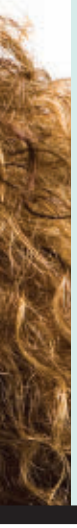
- **ACS SALARIES & SURVEYS**
  www.acs.org/content/acs/en/careers/salaries.html

Getting into graduate school and getting research experience

- **ACS COLLEGE TO CAREER NEXT STEPS**
  www.acs.org/content/acs/en/careers/college-to-career/next-steps.html
- **ACS PREPARING FOR GRADUATE SCHOOL**
  www.acs.org/content/acs/en/education/students/graduate/gradschool.html

Choosing a school, the application process, and what to expect

- **ACS GRADUATE SCHOOL REALITY CHECK**
  www.acs.org/content/dam/acsorg/education/students/graduate/gradschool/graduate-school-reality-check.pdf
- **WEBINAR SERIES, PART 1**
  www.youtube.com/watch?v=nnOF5XOikpA



and even a macaroni-and-cheese budget will probably require some supplemental funding from student loans, personal savings, a gainfully employed spouse, or a family benefactor.

Some graduate programs, particularly at the master's level, are designed for part-time students who are also holding down jobs. The drawback here is that completing these degrees can take a very long time, and balancing the demands of a job with even one or two classes a semester (not to mention a research project) can be exhausting. Doctoral programs generally require you to be a full-time student, although it's not unheard of for doctoral students to bring in a little extra money as tutors, bartenders, freelance photographers, or other types of work.

Even if you're not holding down a job while you study, graduate studies are a major investment of time and energy. If you have a spouse and children, they may begin to feel your absence acutely as you get deeper into your studies and research program. Your children may be too young to fully understand what's going on, but getting your spouse's support before you begin is critical to your success. This is especially true if your family must move with you to the town where your university is.

Are you planning to enter a field where the jobs are concentrated in one geographical area? If so, are you (and your family) willing to live where the jobs are? Many chemical manufacturing companies are located on the Gulf Coast. Many pharmaceutical companies are located in the Northeast. Software developers gravitate toward Silicon Valley. Academic positions usually require you to live in the town where the college or university is located. Although you can find positions in other locations, you are more likely to be able to advance and switch companies (after a job loss or otherwise) if you live in an area where several companies in your field are located.

If you will be leaving a full-time job to return to school, develop a budget that reflects your grad-school income level. Think through the implications of being out of the workforce for several years — will the advance in career satisfaction and job status after you graduate be enough to compensate for the loss of income and advancement while you're in school? Of course, no one can know for certain what the future holds, but it's worth giving it some thought.

Focus, with flexibility

"I'm only 19. How can I pick something that I can do for the rest of my life?" The short answer is, you probably won't be doing any one specific thing for the rest of your life. School should equip you with a set of basic abilities, like identifying interesting problems to work on or designing experiments to tackle specific questions. As you progress through your career, you will be adding other skills and abilities and discovering new areas that interest you.

You can't know everything going in, but it helps to have a general sense of direction. Will you be training for a specific industry sector or career path? Are you interested in a specific field of research? Are you more interested in generating new knowledge, or applying existing knowledge? Focusing on one specific direction will help you choose the best graduate program for you, and it will help you stay on course to finish your degree. At the same time, remember that you're picking this one area as a way of focusing in, not shackling yourself permanently to one possibility.

Some graduate programs focus on preparing students for jobs in specific industry sectors. More commonly, graduate students focus on research projects in a very specialized area, becoming world experts in their own particular niches. Success in the larger career world requires choosing a graduate research area that, even though it's narrowly focused, supports progress toward a long-term objective and picking up experience that will be useful later on.

For example, your research project could require you to become very proficient in the use of one or more types of

laboratory instruments, or you could learn to write computer programs and create visualizations of your data. You could master a particular type of synthesis and apply this knowledge to designing new synthesis methods. Perhaps your knowledge of statistics gives you the ability to evaluate published studies to see whether the results support the authors' claims. Critical thinking, problem solving, independent research, and collaboration skills are all things that you can apply in any career you might find yourself in.

Choosing a specific area of interest will help you research the type of educational background needed to land a job in that area, as well as select a type of graduate program and a few candidate schools. Be aware, however, that your chosen field could undergo a rapid and unexpected expansion or contraction while you're working on your degree, and the job market could look very different by the time you graduate. If the career sector you're preparing for takes a nose-dive while you're in school, it may be hard to change directions. Building in some flexibility will help you adapt.

Making the decision

For some new graduates, moving on to graduate school is a foregone conclusion. For the rest of us, it's a major decision that requires some idea of why you're undertaking this effort. Your reasons and motivations might change over time, but some sense of focus and purpose are essential to choosing a graduate program that fits your needs and to staying motivated over the long run. Having a general idea of the time and financial resources you will need and how to gather those resources will help you go in with a sense of confidence. For many people, taking some time to work after their bachelor's degree gives them this sense of direction, and it allows them to build up their resources before returning to school.

Even though many graduate programs focus on exploring one specific area of research or preparing for one specific industry sector, a sense of flexibility will be necessary after you graduate. Industries change, your interests evolve, and new fields emerge. Bear this in mind, keep your eyes and ears open, and enjoy the ride. iC

Nancy McGuire *is a freelance writer based in Silver Spring, MD. She has a Ph.D. in solid state chemistry and began her career doing applied research.*

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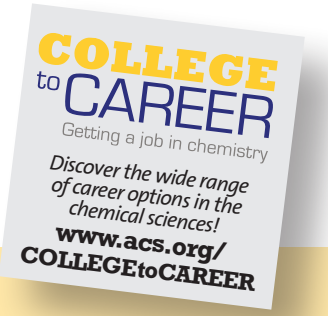
This article is presented in recognition of the International Year of Crystallography and efforts to increase public awareness worldwide of the science of crystallography.

COLLEGE to CAREER

Explore Career Options in Crystallography

BY NANCY McGUIRE



Crystallography is the science that examines crystals, which can be found everywhere in nature—from salt to snowflakes to gemstones. The properties and inner structures of crystals help scientists to examine the arrangement of atoms in the solid state, and this knowledge is used in fields such as chemistry, physics, and biology.

What crystallographers do

Crystallographers use X-ray, neutron, and electron diffraction techniques to identify and characterize solid materials. They commonly bring in information from other analytical techniques, including X-ray fluorescence, spectroscopic techniques, microscopic imaging, and computer modeling and visualization, to construct detailed models of the atomic arrangements in solids. This provides valuable information on a material's chemical makeup, polymorphic form, defects or disorder, and electronic properties. It also sheds light on how solids perform under temperature, pressure, and stress conditions.

Crystal-growing specialists use a variety of techniques to produce crystalline forms of compounds for use in research or manufacturing. They may be experts in working with hard-to-crystallize materials, or they may grow crystals to exacting specifications for use in computer chips, solar cells, optical components, or pharmaceutical products.

Crystallography has become an important tool for studying structural biology. Proteins and other biological materials (including viruses) may be crystallized to aid in studying their structures and composition. Many important pharmaceuticals are administered in crystalline form, and detailed descriptions of their crystal structures provide evidence to verify claims in patents.

Instrument manufacturers hire crystallographers for customer sales and support functions, including instrument repair and helping customers with special projects. Staff crystallographers at the national laboratories develop and maintain leading-edge research instruments and software capabilities. They also assist visiting users in setting up and running experiments using specialized

Quick Facts

- **OPPORTUNITIES**

  Crystallography specialists may find opportunities working in instrument and software development, customer support for instrument manufacturing companies, user support at national laboratories, or working in crystal-growing laboratories.

  Historically, crystallographers have been associated with the geosciences, metallurgy, and ceramics engineering. However, the largest areas of demand today are in the medical and life sciences.

- **EDUCATION NEEDED**

  Laboratory technicians usually require a bachelor's degree in chemistry, biology, geology, physics, or a related field.

  Research positions usually require a Ph.D. and additional experience in a field of specialization (pharmaceuticals, structural biology, geosciences, materials science, physics, etc.). Research associates may have master's degrees and some experience.

  Customer and user support positions may require a graduate degree, depending on the nature and complexity of the service provided. These positions often require practical experience gained on the job, in addition to a strong academic foundation.

- **SALARIES**

  Jobs requiring undergraduate degrees range from $35,000 to $85,000 per year (2010).

  Jobs requiring graduate degrees range from $65,000 to $140,000 per year (2010).

- **LICENSES AND TRAINING**

  Licenses are not generally required for crystallography.

  Crystallographers must take safety training because their laboratory instruments produce X-rays, neutrons, or high-energy electrons. They wear one or more radiation dosimetry devices in the laboratory and must submit these devices for periodic checks to ensure that they have not been exposed to excessive amounts of ionizing radiation.

  Crystallographers working at government agencies or national laboratories may be required to undergo background checks or obtain security clearances on the basis of the nature of the work and the security requirements of the laboratory.

techniques, including synchrotron X-ray diffraction and neutron diffraction. Universities employ staff members to maintain and operate their research laboratories and to train students to use the instruments.

Crystallographers may develop instrumentation and software for collecting, analyzing, and visualizing data and for translating these data into crystal structure models. Some crystallographers maintain and develop archival databases at industrial and academic institutions, as well as some nonprofit organizations and government laboratories.

Service laboratories hire diffraction technicians to prepare and catalog samples, run the data collections, and prepare routine reports on the results. Technicians may also be called on to perform routine instrument maintenance and simple repairs.

Forensics laboratories use crystallography to investigate cases involving product adulteration or counterfeiting. They may identify minerals, metals, or other materials found at crime scenes. They may also identify corrosion products and other residues found at the site of an industrial accident to help verify the events leading up to the accident.

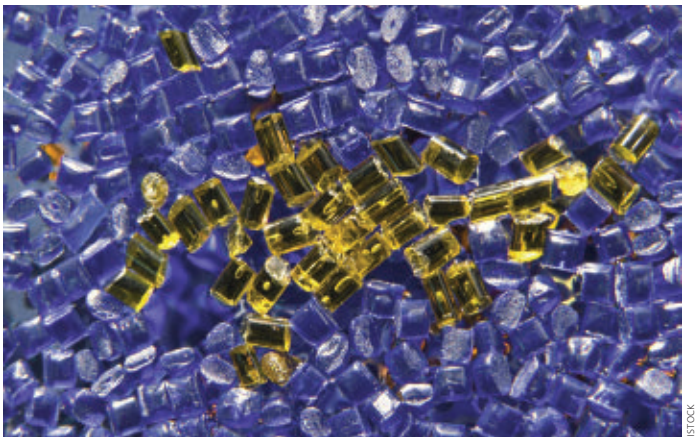
Workspace

Crystallographers generally work in laboratories. Because crystallography is a very computation-intensive specialization, crystallographers must be able to use, and train others on, proper data collection and analysis methods, software packages, and computer visualization capabilities. They may be systems administrators for the computing networks associated with their laboratories.

Crystal-growing labs may have controlled-environment devices, including glove boxes, furnaces, and cryogenic chambers. These spaces must be kept free from contaminants and unwanted sources of vibration or other factors that could damage the crystals as they grow.

Crystallographers in academic environments often teach courses in diffraction theory or provide individualized instruction on using the instruments and software. At national laboratories, crystallographers train visiting users, and they perform their own research and maintain custom-designed instruments, many of which are quite large.

Research crystallographers make presentations at conferences, and they may travel to specialized facilities to run experiments.



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TECHNICAL SKILLS REQUIRED

Required skills vary according to specialization, but may include the following:

- **Problem-solving skills and an interest in solving basic and applied research problems**
- **Critical thinking and analytical skills to design experiments, troubleshoot processes, and analyze data collected**
- **Written and oral communication skills to explain findings and share results with scientists and nonscientists**
- **Computer skills, including familiarity with computer modeling and data analysis**
- **Skills in adapting and integrating computer software to solve new categories of problems**
- **Ability to visualize structures in three dimensions**
- **Crystal-growing capabilities**
- **Instrument maintenance, operation, and development**

Is this career a good fit for you?

Although computer hardware and software have evolved to the point where they perform much of the computation, a crystallographer must understand the underlying principles to set up the calculations properly and ensure that the results are meaningful and properly interpreted. Computers can create 3D models of crystal structures, but an ability to correlate these structures with properties of the material requires an ability to visualize and interpret these models. This requires patience and attention to detail.

Crystallographers must collaborate with experts in synthesis and in other analytical techniques, and often, they must have some degree of expertise across several disciplines. They may be required to develop novel sample configurations, adapt their instruments to new applications, or adapt and create new software capabilities to handle unusual or difficult problems.

Crystallographers, especially technicians, may serve a support function for chemical synthesis labs. They may work in commercial service labs or as a part of an in-house analytical team. This requires them to understand the problem that their customers or colleagues are trying to solve, and to devise a data collection and analysis procedure that provides useful and accurate results. iC

Nancy McGuire *is a freelance writer based in Silver Spring, MD. She has a Ph.D. in solid state chemistry and began her career doing applied research.*

Chemists in the Real World: Brian Toby, Ph.D.

SENIOR PHYSICIST/SECTION HEAD, ARGONNE NATIONAL LABORATORY

PH.D., PHYSICAL CHEMISTRY, CALIFORNIA INSTITUTE OF TECHNOLOGY

B.A., CHEMISTRY, RUTGERS, THE STATE UNIVERSITY OF NEW JERSEY-NEW BRUNSWICK

Brian Toby has worked for eight years at the Advanced Photon Source (APS), a synchrotron-type particle accelerator at Argonne National Laboratory that provides intense X-ray beams to a variety of specialized instruments. His current job title is Senior Physicist and Section Head for Scientific Software. He assists scientists at the synchrotron in automating their instruments, analyzing data, and doing instrument support. He spends much of his time developing a crystallographic data analysis software package, GSAS-II, that can be used with a variety of diffraction instruments and experimental setups. "I see my job as being a resource," he says.

Previously, as a group leader at Argonne, he headed up efforts to build a high-resolution powder diffractometer that is now the APS's most productive instrument, in terms of publications generated using data from the facility. This instrument is highly automated for high sample throughput, so that scientists can mail their samples to the lab and receive their results online, after the data have been reviewed for quality by an Argonne staffer. Toby has done considerable work on automating processes, which enables scientists to spend more time productively, rather than doing repetitive tasks.

Toby learned crystallography as a chemistry undergraduate and then studied surface science in graduate school, receiving his doctorate in physical chemistry in 1986. He landed his first job after graduate school through an on-campus recruiting program. Two companies interviewed him, and one of those companies offered him his choice of jobs in two different locations. Since then, he has worked in industry and academia, before going into government laboratory work.

Please describe your typical day on the job.

My typical day starts by clearing my e-mail inbox. With that out of the way, I then pick up a task I want to work on for the day, which may be writing or editing a paper, putting together a talk, analyzing some data, or adding a feature to some data analysis code. Once in a while I collect data, but I try to give the pleasure of that to my collaborators.

At least a few times each year, I go to universities and conferences to give seminars, or to professional workshops and give tutorials. I have a website where I archive recordings of my tutorials, but eventually, I would like to replace that with a MOOC (massive open online course) where students can interact to help each other solve problems.

What apps/software/ instrumentation/tools can't you live without?

I use the Beamline 11 BM High Resolution X-ray powder diffraction instrument at Argonne to collect data; it is the best resource of its type in the United States. For data analysis, I use the GSAS/EXPGUI and GSAS-II diffraction software packages and the Python programming language. I use the Emacs text editor for writing code, and EndNote for writing papers. I love working on a Mac so that I can alternate between typing Unix commands and the Mac GUI (graphical user interface) features.

How many hours do you work in a typical week?

I probably work 30–45 hours per week in the office and 10–30 more at home. Previously, I had a role with way too many tasks — until I was replaced by four people. For now, my work pace is largely self-driven, but I always have more things I want to do than energy to get them done.

Is there anything else you would like to mention about your career?

I spent two stints in industrial labs, with a non-tenure track university job in between, before starting the first of my two government research jobs. Prevailing wisdom is that does not happen. A lot of people think that once you go into industry, you never leave, but this was not true in my case.

What is your work environment like?

I have a private office; I once turned down a job because scientists were housed in an "open office" environment. I think for a living, and distraction would kill my productivity. I can get quite a bit done with just my laptop while traveling, but many tasks need a really quiet place where I can concentrate. Multiple computer monitors are also great to have.

What essential habit do you have now that you wish you'd started much earlier?

I wish that, when I was a student, it had been possible to receive journal tables of contents by e-mail. I read them for many journals and follow up on a small number of articles. Some I skim, others I look at more carefully. It took me too long to learn that time spent on calendar keeping (meetings, deadlines, etc.) is never wasted.

What is your favorite ACS resource?

The ACS journals and their free e-mail contents/ASAP service. Also, I attended and gave a presentation at an especially well-organized symposium at the ACS national meeting earlier this year. I made some good new professional connections, and I got to speak with a number of old friends. iC

SPOTLIGHT
Saint Mary's College
Notre Dame, IN

COMPILED BY ROBIN LINDSEY

Chapter president: Katherine Bussey **Chapter members:** 21 **ACS student members:** 9
Website: www.facebook.com/SMAACS **Institution description:** Small, private, rural, 4-year

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

A: We have a unique governing system where officers are encouraged to occupy positions for two years. This way there is effective governance for longer periods of time, with smoother transitions between elected officers.

Q: **Do you have any unique positions?**

A: We have a student chapter mascot. This student has a very jovial personality and is responsible for rallying up members during competitive inter-department games against the Biology Club.

Q: **Is your chapter active in recruiting prospective students to your university?**

A: Our chapter's campus events are always open for the entire student body to attend and participate. We use these events as an avenue to meet new students and educate them about the ACS, our student chapter mission, and future events.

Q: **What is your most popular or unique chapter activity?**

A: The most unique activity we have at our institution is a friendly sports rivalry with the Biology Club. We put together a different sporting event each semester and have an engraved running trophy for the winning club to display in their department that semester.

Q: **How involved is your chapter on campus?**

A: We are very involved on campus, organizing several events that involve the student body, faculty, staff, and administrators. One recent example was the Pie-Your-Professor fundraising event we put together, where 16 faculty and staff members, including the president of the college, agreed to get pied by students and colleagues for a donation.

Q: **Do you collaborate with other clubs on campus on activities?**

A: We collaborate with the Biology Club, Mathematics Club, and Engineering Club for an on-campus event called Hypatia Day. About 80 female middle school students from the local community visit our campus for a day and participate in hands-on demonstrations with the clubs.

Q: **What are your most effective communication tools for promoting chapter activities?**

A: We have a large bulletin board in the department where events are posted. We also use Facebook and send e-mails to members.

Q: **If your chapter has recently attended an ACS national meeting, how did members benefit?**

A: Through our fundraising activities, supporting funds from the student government, and two travel grants (one from ACS national, and one from our local ACS section), we were able to send four students to the national meeting in Dallas, TX. They made a research presentation along with a student chapter presentation, and brought back many new ideas for our student chapter to explore in upcoming years. iC

PHOTO COURTESY OF ST. MARY'S COLLEGE

Last year, to help members and friends de-stress before finals, the Saint Mary's College chapter sponsored a bowling night at the end of the fall semester.

Faculty advisor:
Kayode Oshin, 2 years

Q: **How did you become a faculty advisor?**

Oshin: The opportunity was presented to me by the department when I joined Saint Mary's College in 2012. I gladly took on the position, as I wanted to see the student chapter become more involved on campus and in the community.

Q: **What challenges have you faced in your position?**

Oshin: The biggest challenge has been to be aware of various student schedules and to be mindful of them when planning events. Working around different exam schedules and projects is important because the academic success of our student members comes first.

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

Oshin: It has been very fulfilling to help student members put on various outreach events for children in our local community. Our goal is to generate interest in the field of chemistry, stimulating children in attendance to pursue continued education, and hopefully careers, in science, technology, engineering, and math fields.

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

Oshin: Recruit responsible and motivated students to run for open officer positions. Having a strong leadership core helps the student chapter run smoothly and efficiently, and also makes it an enjoyable commitment for the advisor. iC

SPOTLIGHT

Chabot College

Hayward, CA

COMPILED BY ROBIN LINDSEY

Chapter president: Cynthia Chan **Chapter members:** 40 **ACS student members:** 24
Website: www.chabotchemistryclub.com **Institution description:** Small, public, 2-year

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

A: Even though many of the members and officers do not know each other in the beginning, we quickly befriend each other through our events and activities during meetings. This makes transitioning from year to year much easier.

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

A: We have volunteered several times at the Fargo Senior Center, serving the elderly during the Thanksgiving and Christmas dinners. We also helped out in a few science festivals, at which our members served as judges and hosted experiments. Our most recent attendance was the Castro Valley Science Festival, where we helped elementary, middle, and high school students create lava lamps and slime.

Q: **What are your most successful recruiting and retention events?**

A: Our college hosts Gladiator and Club Days, where we display fun experiments in order to attract new members. We also plan many campus tours and host experiments during club meetings in hopes of retaining our members.

Q: **What types of activities do you sponsor?**

A: We plan many campus tours, museum visits, and social events. We try to sponsor transportation when we tour campuses, in an effort to encourage members to attend.

Q: **What is your most successful fundraiser to date?**

A: Our most successful fundraisers are usually the flea markets that our college hosts every month.

Q: **Can you describe any fun social events your chapter has recently had?**

A: We have had social events involving bowling, the Tech Museum, California Academy of Sciences, Famous Dave's, and other activities.

PHOTO COURTESY OF CHABOT COLLEGE

Chabot College chapter members toured San Jose State University and posed with the statue of Olympic track star Tommie Smith, an alumnus of the university.

Faculty advisor:
Laurie Jean Dockter, 2 years

Q: **Why did you become a faculty advisor?**

Dockter: As a member of the ACS for 38 years, I saw the student interest developing and I was excited to take on the role of faculty advisor.

Q: **What challenges have you faced in your position?**

Dockter: The biggest challenge in creating a new student chapter is getting students involved. When we first became an ACS chapter, our college also started a Mathematics, Engineering, Science Achievement (MESA) program to serve financially and educationally disadvantaged students seeking majors in math- and science-based fields. The development of MESA made the creation of the ACS student chapter much easier. Biology and Computer Science/Engineering clubs were also created. The students in these clubs have worked together in planning events.

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

Dockter: Observing the students developing skills they will use in their professional life. The students have been very enthusiastic and creative in developing events. They have worked hard to cover all the objectives that the ACS recommends for student chapters, and also explore additional opportunities.

Q: **What advice do you have for new faculty advisors?**

Dockter: Work with established groups of students to help build up a community of students who can start participating in chapter activities. Also, encourage students to begin working on the new online report form at the beginning of the fall semester.

A Little History… A Lot of Science… Tons of Fun!

The University of Florida Student Chapter's Experience at the USA Science and Engineering Festival and Expo in Washington, D.C.

BY RYAN QUINOÑES AND LAUREN McCARTHY

The 3rd USA Science and Engineering Festival and Expo, held April 24–27, 2014, was an amazing four-day event. For us, the experience of being participants was unlike any other, from the very beginning.

The result of a national grassroots effort to advance science, technology, engineering, and mathematics (STEM) education and inspire the next generation of scientists and engineers, the gathering is the largest STEM event in the United States. The festival is held biennially, and includes a three-day Expo at the Walter E. Washington Convention Center in Washington, D.C.

At the 2014 festival, there were more than 3,000 different hands-on activities and experiments, along with countless scientists, engineers, and students. In addition, there were more than 100 stage shows featuring science magicians, song and dance with science cheerleaders, Bill Nye the Science Guy, and much more.

Three members of the ACS student chapter at the University of Florida (UF), Gainesville, FL, including us, participated as representatives at the UF booth. The delegation at our booth included 23 students from 9 UF student groups, and this was the first year that UF's participants were almost all undergraduates. Each group designed demonstrations and activities to entertain the people who visited our booth. In total, 325,000 people visited the Expo, which meant each booth saw thousands of visitors daily.

Motivation, then preparation

We originally decided to participate in the Expo because it sounded like an incredible opportunity to do outreach to a national community, interact with other student groups, and meet interesting people. Plus, the Expo was being held in Washington, D.C. — and was free! Who wouldn't want to go?

The planning process for this event was not too difficult. Our first task was to choose activities and demonstrations to entertain the audience, which was mostly made up of younger children. For the activities, we chose safe experiments that were easily reproducible on a larger scale. The demonstrations we selected required a few basic materials. We designed them to be dramatic and last approximately 30 minutes.

One of our three activities was "magic breath," a simple neutralization reaction. The other activities involved making two types of slime; one mixed the polyvinyl acetate found in Elmer's glue with borax, while the other mixed polyvinyl alcohol with borax. For our demonstrations, we chose the "imploding can" and the famous elephant toothpaste, a very volatile reaction of potassium iodide and hydrogen peroxide.

Nancy Ruzycki, a UF faculty member, coordinated the shipping of materials to the Expo and handled the logistics of finding lodging and transportation. Nancy was a great resource.

We were responsible for assembling a list of materials to purchase, finding vendors, creating a banner, writing the presentation, and organizing materials for shipment. The tasks related to

WASHINGTON, D.C. PHOTOS: THINKSTOCK

the materials were somewhat critical, as no additional materials were going to be available for us during the Expo itself. As a result, we needed to plan for purchasing everything we needed — including water.

We carefully reviewed the procedures and created spreadsheets for all the materials we needed. Then we categorized the materials into items we already had and items that needed to be purchased. For items that needed to be purchased, we did a simple Internet search to find a vendor. With careful planning, organizing our participation was completely doable, especially with Nancy's aid.

The activities for children

The Oobleck and slime activities were extremely well received. Chemically, the experiments are similar because they show the cross-linked polymerization products that borax forms with polyvinyl acetate and polyvinyl alcohol, respectively. To a chemist, this concept is rather trivial, but to the children in our audience, the results were nontoxic, tangible products that could be felt, played with, and enjoyed! Allowing children to stir the mixture as the reagents were added gave them a feeling of inclusion and stimulated even greater interest. The Oobleck activity even showed off the properties of a non-Newtonian fluid, which intrigued some of the older students.

During the "magic breath" activity, we showed how carbon dioxide exhaled from the lungs generated carbonic acid, which neutralized a basic calcium hydroxide solution (which we colored purple using a phenolphthalein indicator). As the solution became more acidic, the color faded, which astonished the volunteers blowing bubbles into the solution. While this was well received, interest quickly faded, since the effect was quite brief. In contrast, the Oobleck and slime experiments were enjoyed for much longer lengths of time, due to the formation of lasting products.

The demos

The demonstrations drew a large crowd (since everyone loves explosions!), but were relatively short-lived. The elephant toothpaste was our most grandiose performance, using an iodide-catalyzed, exothermic reaction in which oxygen is evolved from concentrated peroxide and captured by adding dish detergent, resulting in a vigorous stream of foam erupting from the mouth of the volumetric flask.

Unfortunately, we only had enough potassium iodide catalyst for one reaction, so we waited until we drew enough people to show it off. We supplemented this event with our can implosion demonstration, which took advantage of pressure changes due to water vapor condensation. While the elephant toothpaste "wowed" everyone, the can implosions served to keep them interested while we explained the processes behind both demonstrations. Since we required cans for crushing, we let the kids drink the soda so we could crush the cans later… with parental permission, of course!

The end result

Overall, both the activities and demonstrations went rather well. We had to adjust the ratios of materials used to make Oobleck, and synthesizing a proper product took up a significant amount of time; however, the slime products were easy to make, and really entertained the children. The calcium hydroxide solutions were a bit messy at times, as solution was spilled due to forceful exhalations from enthusiastic volunteers.

Looking back on our activities, synthetic materials and longer-lasting experiments seemed to function best. When we do similar demos in the future, we'll make sure to obtain more materials in advance.

Experience beyond the Expo

Another great aspect of the Expo overall was the freedom — we were only constrained by our assigned times for the activities and demonstrations. After we completed our assigned time slot, we were free to roam about the historic city of Washington, D.C. This was possible because Nancy had scheduled all of the participating student groups in shifts, which left us ample time to explore different monuments, museums, and other locations at our leisure.

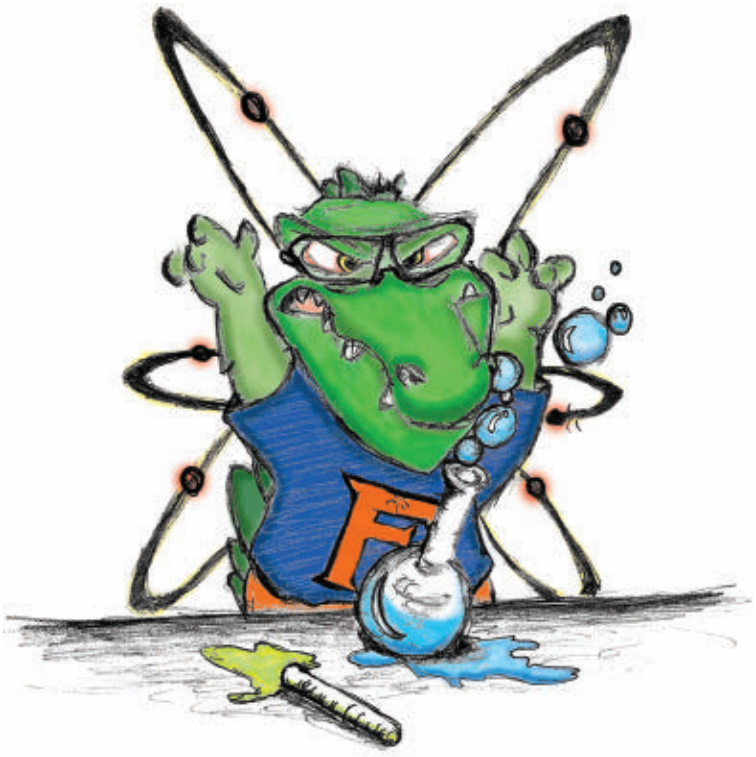
One of us had the pleasure of spending an entire day walking around D.C., and was fortunate enough to visit the Washington Monument, Lincoln Memorial, National Air and Space Museum, National Museum of the American Indian, and the Petersen House, where Abraham Lincoln was taken after he was mortally wounded at Ford's Theatre — again, all in one day. Whereas similar events might demand that one spend almost the entire time working, the Expo was structured to split the duties among all the participating groups, allowing free time to truly absorb what the city has to offer.

Kids who visited the UF booth had opportunities to make slime (pictured above) and Oobleck and to participate in a "magic breath" activity.

Ultimately, participating in the USA Science and Engineering Festival and Expo was a fantastic, one-of-a-kind experience that we would highly recommend to anyone. The experience at the Expo was made even more memorable by receiving recognition packets from ACS for our outreach efforts. The Expo was an incredible way to interact with a younger crowd and get others interested in chemistry, while also getting the chance to explore such an amazing city.

We returned home with new experiences, friends, and memories — overjoyed at having had the opportunity to participate at Expo as representatives of both UF and ACS. From the long 14-hour drives, to meeting fellow student representatives, to interacting with so many individuals, the experience certainly created some unforgettable memories.

With the Expo being such a successful and rewarding experience, our chapter looks forward to sending more ACS student members to participate in the future! iC



UF chapter historian Latoy Waite designed our chapter logo, which was featured on the UF banner at the Expo.

Ryan Quiñones *is a senior chemistry major at UF, where he is involved with the UF student chapter and the Alpha Chi Sigma Professional Chemistry Fraternity.*
Lauren McCarthy *is a junior at UF, where she is majoring in chemistry and is the secretary of her student chapter.*

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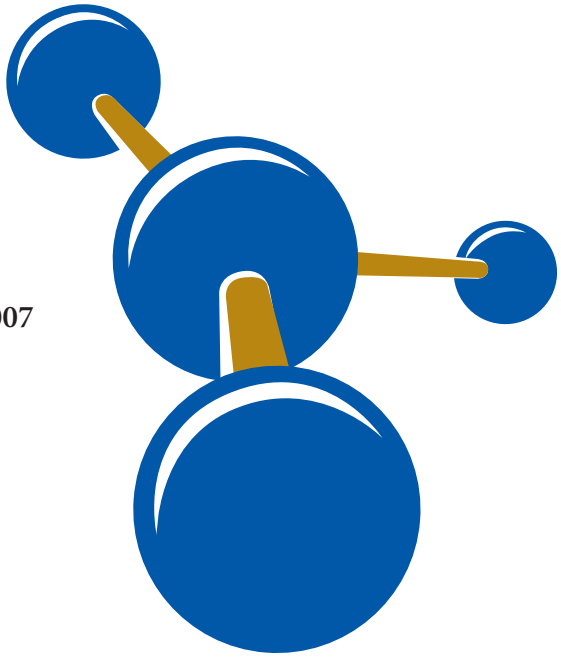

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