



# The San Diego Chemist

American Chemical Society  
Volume 32, Number 2

San Diego Section  
February 2020

## **THE CARDEAN BIOLOGY-GATED TRANSISTOR INFRASTRUCTURE AND INNOVATION PARTNERSHIP PROGRAM – HELPING THE WORLD CONDUCT BIOLOGY**

### **Dr. Brett Goldsmith Co-Founder and CTO of Cardera**

- DATE:** Thursday, February 13, 2020
- TIME:** 6:00 PM Social Hour, Light Meal  
7:00 PM Lecture
- PLACE:** Takeda  
9625 Towne Centre Drive, San Diego
- RSVP:** <https://goldsmith-ACS.eventbrite.com>



#### **ABOUT THE SPEAKER:**

Brett's passion is applying nanoelectronics technology to products that change people's lives. Brett was a post-doc at the University of Pennsylvania as an Intelligence Community Fellow and is the lead researcher on landmark Field Effect Biosensing papers in *Science* and *Nature Nanotechnology*.

#### **ABOUT THE PRESENTATION:**

Cardea's Innovation Partnership Program (IPP) was created to provide a diverse set of partners' access to the company's breakthrough biology-gated transistors and software.

Cardea's new infrastructure is helping the world Conduct Biology™ using the biocompatible material graphene, novel chemistry and electronics to convert biological signals into real-time data. Cardea's first-of-its-kind nanoscale technology infrastructure is already being mass produced (100k transistors/month) - opening a universe of opportunities for portability and scalability.

### CHAIR NOTES

Dear ACS Members,

2020 is off to a great start! We had our first Executive Committee Meeting on Thursday, January 9. We discussed our 2020 budget, upcoming events, as well as outreach activities like Project SEED, Mad Science, and new volunteer opportunities.

Our January outreach event on January 11 was the Pure Water Demonstration Facility Tour: the process of reusing toilet water and making purified water. We learned this purified water is pumped into Miramar reservoir as a safety buffer before entering the process to make tap water. We were reminded that we are "downstream" of 399 other water treatment plants that our drinking water may consist of. We are currently scheduling more water facilities tours in the coming months – let us know if you are interested.

Our February 13 event is a seminar by **Dr. Brett Goldsmith**, Co-Founder and CTO of Cardea, a local company that produces graphene transistors. These are used to produce Field Effect Biosensing (FEB), which combines the capabilities of Graphene Field Effect Transistors (GFETs) and Biological Field Effect Transistors (BioFETs) into one. Come to the talk to learn more about this technology!

We are in need of ACS volunteers for some upcoming, community-wide, large-scale events:

1. San Diego Festival of Science & Engineering's EXPO DAY at PETCO Park, Saturday, March 7, 10 AM – 5 PM
2. Greater San Diego Science & Engineering Fair at Balboa Park, Judging Day, Wednesday, March 11, 12:15 PM
3. San Diego EarthWorks' 30<sup>th</sup> Anniversary EarthFair 2020, Balboa Park (the world's largest free Environmental Fair and Earth Day Celebration), Sunday, April 19, 10 AM – 5 PM
4. Chemistry Olympiad at The University of San Diego, Shiley Center for Science and Technology, March 21 and 22 (Sat. and Sun.) from 9-11 AM

Our next Executive Committee Meeting will take place on Thursday, February 6, at 6 PM. I invite all members who wish to become more involved to please join us. Bring your enthusiasm, your ideas, and your unique talents to help make 2020 an outstanding year for the San Diego Local Section of the ACS!

James T. Caldwell, Ph.D., 2020 Chair  
San Diego Section of the American Chemical Society  
E-mail: [jcaldwell@sandiegoacs.org](mailto:jcaldwell@sandiegoacs.org); Web: [www.sandiegoacs.org](http://www.sandiegoacs.org)

### NON-PROFIT ORGANIZATIONS!

Does your non-profit organization have an upcoming event that might be of interest to members of the ACS – San Diego Section? If so, please send your announcement to our 2020 Chair, **James Caldwell**, at [jcaldwell@sandiegoacs.org](mailto:jcaldwell@sandiegoacs.org). Once approved, James will see that your announcement is published on our website ([www.sandiegoacs.org](http://www.sandiegoacs.org)) and, if received by the 20<sup>th</sup> of the month before the event, in *The San Diego Chemist* newsletter. This is a free service of the ACS – San Diego Section. Take advantage of it!

### ATTENTION ADVERTISERS

**Did you know** that *The San Diego Chemist* is the only monthly e-newsletter that targets chemists and chemical engineers in San Diego and Imperial Counties? As soon as our newsletter is uploaded on [www.sandiegoacs.org](http://www.sandiegoacs.org) a separate notification is sent to the **2,500 members** of the ACS-San Diego Section, each potential customers for your products and services! **Quick turnaround:** Ad copy submitted by the 20<sup>th</sup> of each month will be published by the end of that month.

For more information, please contact:  
**Renate Valois** at [renate@sandiegoacs.org](mailto:renate@sandiegoacs.org)

**THE SAN DIEGO CHEMIST**, the official newsletter of the San Diego Section of the American Chemical Society, published on a monthly basis, can be viewed at <http://www.sandiegoacs.org/newsletter/>.

All contents are published at the discretion of the Section's Executive Committee. Events of interest to chemistry professionals in the community may be included in the events calendar as space permits and are subject to editing for brevity. Advertisements and announcements from the chemistry community are accepted at published rates. The deadline for items submitted is **the 23<sup>rd</sup> of the month** for publication by the end of that month.

**Advertisers:** Ad prices as of January 1, 2015:  
Size (w x h) Number of Issues & Price/Issue

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2" x 3"	\$ 75	\$ 68	\$ 58
4.5" x 1.5"	\$ 80	\$ 74	\$ 67
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full page	\$655	\$590	\$510

Discounts will be available for issues not shown  
Please send your jpg to:

**Renate Valois** at [renate@sandiegoacs.org](mailto:renate@sandiegoacs.org).

### SECTION E-MAIL LISTSERVER!

Get up-to-the-minute reminders of local events and develop dialogs with your fellow members!

To subscribe to our moderated listserver:

1. Send an e-mail with SUBSCRIBE TO LISTSERVER in the subject line, and your name and e-mail in the body of the message to **Ken Poggenburg** at [jkp135@att.net](mailto:jkp135@att.net).
2. If you receive a message from the postman, reply to confirm that you wish to be added to the list, otherwise it will not take effect.
3. You will receive reminders approx. 5-7 days prior to upcoming events and messages of general interest to members.
4. To post topics for discussion, or informational items to the listserver members, send the message to [sandiego-chemist-l@ucsd.edu](mailto:sandiego-chemist-l@ucsd.edu).
5. If the moderator approves the post, it will be sent to the members.

**NOTE:** That is the letter "l", not the number "one" following the word "chemist".

### Executive Committee Meeting Dates 2020

6:00 – 8:00 pm

Thursday	February	6
Thursday	March	5
Thursday	April	2
Thursday	May	7
Thursday	June	4
Thursday	July	9
Thursday	August	6
Thursday	September	3
Thursday	October	1
Thursday	November	5

Meetings will be held at:

**WuXi AppTec,**  
**6122 Nancy Ridge Drive, San Diego**

### **CHEMISTRY JUDGES NEEDED**

Judging by professional societies at the 66<sup>th</sup> Annual Greater San Diego Science & Engineering Fair will take place on **Wednesday, March 11<sup>th</sup>, at 12:15 pm** in Balboa Park. If anyone is able to help choose exhibits for our Section's chemistry awards or wants more information, please contact **Ken Poggenburg** at [jkp135@att.net](mailto:jkp135@att.net)

### **VOLUNTEERS NEEDED EARTHFAIR**

**Sunday, April 19, 2020, Balboa Park • 10am - 5pm**

San Diego ACS volunteers will set up a table in the Children's Activity Area. This special area has crafts, games, face painting, storytelling, and hands-on activities for children of all ages. Activities are intended to educate, entertain and inspire youth, in the spirit of Earth Day.

Please contact **James Caldwell**, [jcaldwell@sandiegoacs.org](mailto:jcaldwell@sandiegoacs.org), to volunteer Sunday, April 19, 2020. We need 3-4 persons for each of the 3-4 hour shifts on April 19<sup>th</sup>. Please support us and share your care for our earth, chemistry education, and the San Diego ACS!

### **CHEMISTRY OLYMPIAD VOLUNTEERS NEEDED**

Dear Colleagues,

We are hosting the Chemistry Olympiad and the preliminary screening is scheduled on **March 21 and 22 (Sat and Sun) from 9-11 am at the University of San Diego in the Shiley Center for Science and Technology**. I would like to ask if you would be interested in proctoring on either day or both. Ideally, we would like to have 7-8 volunteers (3-4 volunteers per day). We ask volunteers to arrive ~ 30-45 minutes to help set-up, register students, then proctor the 2-hour exam and hand out certificates after the test.

Please let me know.

Thank you,

Joan Schellinger at [jschellinger@sandiego.edu](mailto:jschellinger@sandiego.edu)

#### **Addition Important information for proctors/volunteers:**

Please come 30-45 minutes early to help set-up rooms and tables and register/check the names of the students.

Registration information: Please check the student's name in the registration form and have them double check the information listed (especially the email address). If their names are not registered, please have them fill out the form. We can only accommodate another 10-15 unregistered students.

Exam will be conducted for 2 hours. Extra time is not allowed. Proctors are not allowed to answer any questions related to the exam questions.

We provide the following: ACS exam, Scantron paper, scratch paper. All of these should be collected after the exam.

Only non-programmable calculators are to be used on the national exam and on the ACS Local Section exam, if used. The use of a programmable calculator, cell phone, or any other device that can access the Internet or make copies or photographs during the exam are grounds for disqualification.

We provide certificates at the end of the test.

Feel free to bring things to do, read or work on during the 2-hour proctoring period.

Joan Schellinger, PhD

Assistant Professor, Department of Chemistry and Biochemistry, University of San Diego, (619)260-7960

### **Call For Nominations: ACS Fellows Program**

The American Chemical Society (ACS) Fellows Program was created by the ACS Board of Directors in December 2008 to recognize members of ACS for outstanding achievements in and contributions to science, the profession, and the Society. Read more about the [program purpose here](#).

The nomination period for the 2020 Class of ACS Fellows opens on **February 1, 2020. It will end at 11:59 PM on April 1, 2020.**

Use link for guideline from ACS National:

[https://www.acs.org/content/dam/acsorg/funding/fellows/acs-fellows-program-guidelines\\_2018.pdf](https://www.acs.org/content/dam/acsorg/funding/fellows/acs-fellows-program-guidelines_2018.pdf)

If the volunteer work done by the nominee was performed on behalf of the San Diego Section, the chair or a designee from the executive committee familiar with the service or scientific work will be happy to write a nominating letter. The overall purpose of the program is to recognize the top 1-2% of scientists or volunteers in the ACS. People who are generously compensated will not be considered. Contact **John Schindler** at [jwschind@sbcglobal.net](mailto:jwschind@sbcglobal.net) for assistance.

### **ACS-Hach Programs**

#### **ACS-Hach Post-Baccalaureate Teacher Scholarship**

Provides financial support for chemistry graduates with limited work experience to obtain a masters degree in education or teacher certification in chemistry.

**Award Amount:** Up to \$6,000 for full-time study and up to \$3,000 for part-time study

**Application Period: ends April 1st**

#### **ACS-Hach Second Career Teacher Scholarship**

Provides financial support for chemistry professionals to obtain a masters degree in education or teacher certification in chemistry.

**Award Amount:** Up to \$6,000 for full-time study and up to \$3,000 for part-time study

**Application Period: ends April 1st**

#### **About ACS-Hach Programs**

The ACS-Hach Programs provide financial support for future and current high school chemistry teachers. [Learn more.](#)

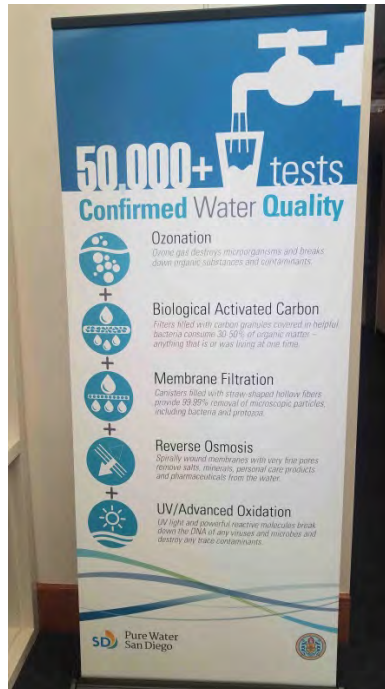
Contact us: Email: [hach@acs.org](mailto:hach@acs.org) -- Phone: (800) 227-5558 ext. 8178

**PURE WATER DEMONSTRATION FACILITY TOUR:  
THE PROCESS OF REUSING TOILET WATER AND MAKING PURIFIED WATER**

The City of San Diego is moving forward with Pure Water San Diego, currently in the first phase, an initial water purification facility that will produce 30 million gallons per day and will be in operation by 2021. The long-term goal, producing 83 million gallons of purified water per day (1/3 of San Diego's future drinking water supply) should be reached by 2035.

In an informative presentation on January 11, we learned about San Diego's water supply challenges and how water purification provides a reliable, sustainable and cost-effective drinking water supply for San Diego. We then took a guided walking tour through the Pure Water Demonstration Facility, where proven technology is used to clean recycled water to produce safe, high-quality drinking water through a 5 step process: ozonation, biological activated carbon, membrane filtration, reverse osmosis and advanced oxidation with ultraviolet light. The treated sewer water is purified to very high standards and then pumped into the Miramar reservoir.

Tour participants saw the equipment up close with a guided tour of the demonstration facility. The facility was undergoing construction; therefore, participants were not offered to taste a sample of the purified water.



James Caldwell



John Schindler



**SUMMARY OF THE SAN DIEGO SECTION  
EXECUTIVE COMMITTEE MEETING MINUTES  
January 9, 2020**

Minutes Nov. 2019 – Approved

Treasurer's Report – Transferring responsibilities to Desiree not complete so Graeme will continue until signature authority can be transferred; year-end summary – \$5K surplus but dividends need to clear before we have funds sufficient in checking, so carrying over \$6.5K in expenses: reimbursements to Graeme, David Wallace for National Meeting expenses, Holly for Website maintenance, one Mad Science program; in actuality, the Section came close to budget; projected 2020 budget: \$18K allotment for 2020 councilor travel (increased from 2019) because both meetings require travel; \$22K proposed sponsorship income; ChemExpo allotment increased based on recent expenditures, Distinguished Scientist Banquet budget lowered assuming we will repeat using the less costly venue; MedChem Symposium allotment up to \$7K; Section didn't spend as much on meeting food in 2019 as budgeted so decreased proposed budget for 2020; Section administration expenses held constant because costs have been nearly constant for several years; Project SEED requesting new funds to add a boot camp for students and mentors to meet as a group to preview expectations of each (anticipate 20 – 25 attendees) so requesting \$11K for 2020; suggestion to add cancellation option to Eventbrite as one means to reduce food wastage; Newsletter preparation unchanged; request to add \$1K for Law Committee; budgeting greater amount for Earth Fair; proposing to sell \$10K of Vanguard stock to refill checking account; Graeme will make adjustments to proposed budget to be presented in Feb. for formal acceptance.

Motion: sell \$10K from Vanguard Fund - Approved

Monthly Seminars – Jan. 11 - Pure Water tour; March – Chemistry of Wine; April - chemistry of tattoos and tattoo removal or chemistry of dentistry; May – SDSU, Festival of Science and Engineering Expo, Greater San Diego Science Fair

Mad Science - Tom will be negotiating for another series of Mad Science programs later this month; after viewing the program, students typically write a summary of the experience

ChemExpo – Proposing Oct. 24, if Miramar College available, theme: adhesives; considering a duct tape design competition

Innovative Program Grant – Ideas: arrange a seminar on chemistry of home brewing

JOURNY's – Continue support at \$500 per issue

STEM Teacher Round table – Feb. 4, asking for 1 volunteer; Val will attend and discuss Project SEED

High Tech Fair – At Fleet Science Center, needing volunteers to participate, SD ACS would need to pay \$100 for table space

Career Shadows – Looking for volunteers where high school students shadow mentors at workplace

National Organic Symposium – Coming to San Diego in 2021

2022 Western Regional Meeting – Scheduled for Las Vegas, hoping to include biotech firms from San Diego, organizing committee asking SD ACS to help in organizing

Next Meeting: Feb. 6, 2020



**31st ANNUAL SYMPOSIUM**

**Friday, February 7, 2020 | 1:00PM – 5:30PM**

**Scripps Research Auditorium:** 10620 John Jay Hopkins Drive, San Diego, CA 92121

**Hosted by:** Department of Chemistry | chemsem@scripps.edu | (858) 784-2400

**DISTINGUISHED SPEAKERS**

**VÉRONIQUE GOUVERNEUR** - Professor of Chemistry, **University of Oxford**

**TIMOTHY M. SWAGER** - John D. MacArthur Professor of Chemistry, **Massachusetts Institute of Technology**

**FRANCES H. ARNOLD** - Linus Pauling Professor of Chemical Engineering, Bioengineering & Biochemistry, **California Institute of**

**Technology**

**AMIR H. HOVEYDA** - Patricia and Joseph T. '49 Vanderslice Millennium Chair, **Boston College**

**SPONSORSHIP OPPORTUNITIES** Sponsorship opportunities are available for our upcoming nationally recognized Symposium. Donations typically range from \$1,000-\$10,000. Donors will be generously acknowledged on our webpage, in printed materials and at the event. If you are interested, please let us know of your intentions to sponsor by October 25, 2019, so that appropriate acknowledgments can be included in our print advertisements.

[www.scripps.edu/frontiers-in-chemistry](http://www.scripps.edu/frontiers-in-chemistry)

## **CHEMPLOYMENT 798**

### **Position Title**

Marketing Associate  
Full time with Benefits

### **Responsibilities include, but not limited to the following:**

- Assist the marketing manager in strengthening the business connection & collaboration with current clients.
- Set up and assisting the marketing manager at national meeting/tradeshows.
- Be responsible for inside marketing work, such as Email campaign, Social Media, LinkedIn, Facebook and Twitter, Web SEO.
- Analyze performance of marketing campaigns and feeding in information to marketing and planning further campaigns.
- Assist sales department with daily sales tasks if needed.

### **Requirements:**

- Bachelor's or Master's degree in Organic Chemistry is required.
- Professional, punctual, detail-oriented, reliable and self-motivated.
- Must have excellent communication skills, verbal & written.

### **Description of Company**

BroadPharm is a leading customer-focused biotech company in San Diego, California. We are dedicated to manufacturing and supplying high purity PEG linkers, Click Chemistry Reagents and advanced Bio-labeling reagents such as Dye Labeling and Biotin Labeling compounds to our clients worldwide. With our strong expertise in modern chemistry, innovative & novel PEG technology and state-of-the-art equipment, BroadPharm can help our customers to accelerate their research through cost-effective and efficient solutions.

### **Contact Information:**

- Please email your résumé to [h Zhang@broadpharm.com](mailto:h Zhang@broadpharm.com) or [ttu@broadpharm.com](mailto:ttu@broadpharm.com).
- No walk-ins or phone calls regarding this job, please.
- No recruiters please.

### **Online Planner with Technical Program Available for Spring 2020 National Meeting**

Plan your ACS Spring 2020 National Meeting & Expo experience with the [Online Planner](#). View the technical program, customize your schedule before the meeting starts, and sync to the Spring 2020 event in the ACS Meetings & Events mobile app when it launches.

Kick off your time in Philadelphia on Sunday, March 22, with the Opening Session around the meeting theme, *Macromolecular Chemistry: The Second Century*. Then join us in the Expo for the Welcome Reception!

On Monday, March 23, the Kavli Foundation Lecture Series will promote groundbreaking discoveries and public understanding of the world's mounting challenges and how chemistry can provide solutions. The series features:

- Prof. Cesar de la Fuente – University of Pennsylvania, The Kavli Foundation Emerging Leader in Chemistry Lecture
- Prof. Omar Yaghi – University of California, Berkeley, The Fred Kavli Innovations in Chemistry Lecture

[Register and book housing now](#) to join ACS and your colleagues in Philadelphia!

## **CHEMPLOYMENT 799**

### **Position Title**

QC/ QA Chemist  
Full time with Benefits

### **Responsibilities include, but not limited to the following:**

- Product analysis using HPLC & LC/MS analytical instrument.
- Develop analytical methods for new product analysis.
- Generate Certificate of Analysis from raw data.
- Devise procedures to inspect and report quality issues.
- Process and conduct investigations into product complaints with quality relevance.
- Participate on project teams, serving as the QA representative and escalate issues to upper management when appropriate.
- Review and disposition of finished product(s) batch records for development and commercial distribution in a timely manner.
- Maintain tracking logs for quality systems.
- Prepare reports for upper management.
- Review of key statistics such as documentation review and internal audits.
- Report all malfunctions to production executives to ensure immediate action.
- Facilitate proactive solutions by collecting and analyzing quality data.
- Keep records of quality reports, statistical reviews and relevant documentation.
- Ensure all legal standards are met.
- Communicate with external quality assurance officers during on-site inspections.
- Other essential duties as assigned.

### **Requirements:**

- Bachelor's or Master's degree in Analytical Chemistry or Organic Chemistry is required NMR, HPLC and LC/MS experience
- Must have attention to detail, be a critical thinker and have effective organizational skills
- Strong written and oral communication skills
- Reliable and Trustworthy
- Maintain a professional, positive and enthusiastic demeanor when communicating with clients and internal staff
- Ability to solve problems, drive results and work collaboratively in a team environment

### **Description of Company**

BroadPharm is a leading customer-focused biotech company in San Diego, California. We are dedicated to manufacturing and supplying high purity PEG linkers, Click Chemistry Reagents and advanced Bio-labeling reagents such as Dye Labeling and Biotin Labeling compounds to our clients worldwide. With our strong expertise in modern chemistry, innovative & novel PEG technology and state-of-the-art equipment, BroadPharm can help our customers to accelerate their research through cost-effective and efficient solutions.

### **Contact Information:**

- Please email your resume to [h Zhang@broadpharm.com](mailto:h Zhang@broadpharm.com) or [ttu@broadpharm.com](mailto:ttu@broadpharm.com).
- No walk-ins or phone calls regarding this job please.
- No recruiters please.

## CEMPLOYMENT 800

### **Position Title:**

Office Chemist. No laboratory work. Starting with 4-hour job a day until full-time employment.

### **Job Description:**

- 1) Chemicals valuation using chemical structure, synthesis route and raw material costs as well as vendors' price collecting. In short "chemicals' appraiser".
- 2) Communication with customers and vendors.
- 3) Writing shipping documents, packing and shipping chemicals
- 4) Any other work needed for proper office operation.

### **QUALIFICATIONS DESIRED:**

#### **Education**

Synthetic organic chemistry education, preferably PhD, at least M.S. in organic chemistry. Quick learner capable to handle dozens of projects simultaneously and to respond to up to 50 emails per day. Multi-tasking is a prerequisite, but not at the expense of quality. PERFECT ENGLISH IN WRITING AND SPEAKING!

#### **Experience**

At least 5 years, better much more, as a synthetic organic chemist at research and development department. Experienced chemical software and online services user as follows: ChemOffice, ISIS, SciFinder, ChemSpider, Pubchem, MicrosoftOffice. Thunderbird and other common programs.

#### **Description of Company**

Founded in Austria in 1990, opened a branch office in the USA in 2008, Aurora became the biggest supplier of chemicals to Chemcat, PubChem and ChemSpider. Aurora manufactures and markets unusual and valuable chemicals of high purity for research and development. [www.aurorafinechemicals.com](http://www.aurorafinechemicals.com)

#### **Application Instructions**

If you are tired of laboratory routine but still want to work using your chemical experience and skills, you are in the right place.

Please mail or fax your résumé with a subject line "Office Chemist" to [aurora@aurorafinechemicals.com](mailto:aurora@aurorafinechemicals.com)  
Fax: 858-549-4701

### **ACS Webinars™**

Welcome to ACS Webinars, your source for online live and on-demand content, created by the American Chemical Society. **Please join us weekly, Thursdays at 2pm ET.** [For more information and upcoming Webinars see: https://www.acs.org/content/acs/en/acs-webinars.html](https://www.acs.org/content/acs/en/acs-webinars.html)



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Email: [Desurya@suprasciences.com](mailto:Desurya@suprasciences.com); Tel: 858-337-4961

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e3 CIVIC HIGH

# JOB SHADOW DAY

FRIDAY MARCH 6TH



\* Provide an experience that allows an e3 scholar to observe and/or participate in the workplace for approximately 4 - 6 hours at your place of business.

\* While the scholar is there we encourage you to perform your normal activities, but willing to answer questions from the scholar and explain what is happening and why.



**- 4 Hour Experience**

8:30 am start time with an ending time at 12:30 pm.

**- 6 Hour Experience**

8:30 am start time with an ending time at 2:00 pm.



For more information contact:

**Melissa A. Woods**

**Internship & Workforce Development Coordinator**

**mwoods@e3civichigh.com**

**619 546-0000 x2725**



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**2020 ACS REGIONAL MEETINGS**

Central Regional (CERM)	May 27 - 29	Columbus, Ohio
Middle Atlantic (MARM)	June 12	New York, NY
Northwest (NORM)	June 28 - July 1	Bellingham, WA
Southwestern/Southeastern (SWRM/SERMACS)	October 14	New Orleans, LA
Northeast Regional (NERM)	October 18-21	Rochester, NY

**ATTENTION COMPANIES!**  
**Do you hire student workers?**

If you have open positions in chemistry and biochemistry that would be of interest to college students, such as summer internship opportunities, here is a list of contacts you'll want to keep handy. The people listed below are the faculty advisors of the ACS Student Affiliate groups for all chemistry programs in San Diego County. These professors can get the word out to all chemistry and biochemistry majors at their schools about jobs, career fairs, open houses, etc.

**California State University, San Marcos**  
 Jacqueline Trischman  
[trischma@csusm.edu](mailto:trischma@csusm.edu)  
 760-750-4206

**Point Loma Nazarene University**  
 Sara Choung  
[SaraChoung@PointLoma.edu](mailto:SaraChoung@PointLoma.edu)  
 619-849-2627

**San Diego Mesa College**  
 Dwayne Gergens  
[dgergens@sdccd.edu](mailto:dgergens@sdccd.edu)  
 619-388-2609

**San Diego Miramar College**  
 Fred Garces  
[fgarces@sdccd.edu](mailto:fgarces@sdccd.edu)  
 619-388-7493

Linda Woods  
[lwoods@sdccd.edu](mailto:lwoods@sdccd.edu)  
 (619) 388-7750

**Southwestern College, Chula Vista**  
 David Hecht  
[dhecht@swccd.edu](mailto:dhecht@swccd.edu)  
 619-421-6700x5461

**University of California, San Diego**  
 Stacey Brydges  
[sbrydges@ucsd.edu](mailto:sbrydges@ucsd.edu)  
 858-246-0993

Thomas Bussey  
[tbussey@ucsd.edu](mailto:tbussey@ucsd.edu)  
 858-822-6665

**University of San Diego**  
 Tammy Dwyer  
[tdwyer@sandiego.edu](mailto:tdwyer@sandiego.edu)  
 619-260-4030

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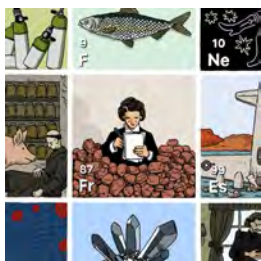
A two-month ad costs only \$80.00  
 For information contact: **Renate Valois -**  
[renate@sandiegoacs.org](mailto:renate@sandiegoacs.org)



## THE HISTORIES HIDDEN IN THE PERIODIC TABLE

From poisoned monks to nuclear bombs, mapping the atomic world hasn't been easy.

By Neima Jahromi, The New Yorker, December 27, 2019



As element hunters have become element makers, the periodic table's meaning has changed. It now describes what is possible, in addition to what merely exists.

The story of the fifteenth element began in Hamburg, in 1669. The unsuccessful glassblower and alchemist Hennig Brandt was trying to find the philosopher's stone, a mythical substance that could turn base metals into gold. Instead, he distilled something new. It was foamy and, depending on the preparation, yellow or black. He called it "cold fire," because it glowed in the dark. Interested parties took a look; some felt that they were in the presence of a miracle. "If anyone had rubbed himself all over with it," one observer noted, "his whole figure would have shone, as once did that of Moses when he came down from Mt. Sinai." Robert Boyle, the father of modern chemistry, put some on his hand and noted how "mild and innocent" it seemed. Another scientist saw particles in it twinkling "like little stars."

At first, no one could figure out what the Prometheus of Hamburg had stolen. After one of Brandt's confidants provided a hint—the main ingredient was "somewhat that belong'd to the Body of Man"—Boyle deduced that he and his peers had been smearing themselves with processed urine. As the Cambridge chemist Peter Wothers explains in his new history of the elements, "[Antimony, Gold, and Jupiter's Wolf](#)" (Oxford), Brandt's recipe called for a ton of urine. It was left out in buckets long enough to attract maggots, then distilled in hot furnaces, creating a hundred and twenty grams of "cold fire." Brandt believed that, if he could collect enough of this substance, he might be able to create the philosopher's stone. In 1678, the Duke of Saxony asked him to collect a hundred tons of urine from a garrison of soldiers and render it into what Boyle and others soon started to call phosphorus—Latin for "light-bearer."

The soapy phosphorus that Brandt cooked up was a curiosity. But, in England, Boyle began producing it in a purer, more solid form, which turned out to be highly flammable. Another scientist toying with Boyle's phosphorus found that, "if the Privy Parts be therewith rubb'd, they will be inflamed and burning for a good while after." Boyle, for his part, wondered whether it could be harnessed as a starter for gunpowder. (His assistant, the apothecary Ambrose Godfrey, set his head on fire and burned "two or three great holes in his breeches" while investigating the substance.) The phosphorus industry grew throughout the eighteenth century, in part because physicians wrongly believed that it had medicinal value. In the eighteenth-hundreds, match producers found that wood splints tipped with phosphorus were less dangerous than their sulfur-coated predecessors; not long afterward, the discovery that electric furnaces could extract phosphorus from ore at a large scale led to the development of explosives. In the Second World War, in what Wothers calls "a tragic twist of fate," Hamburg, Brandt's home town, was destroyed by Allied bombers dropping phosphorus munitions.

Wothers finds many such twists in the stories hidden behind the squares of the periodic table. Antimony (element No. 51) is a lustrous mineral; four thousand years ago, people carved vases out of it, and it appears in cosmetic regimes described in the Old Testament. According to an account given by the seventeenth-century apothecary and alchemist Pierre Pomet (offered up by Wothers as possibly apocryphal), antimony got its name from the story of a German monk who fed it to his fellow-brethren. The monk had given some to a few pigs, who vomited at first but then grew healthy and fat. Unfortunately, every monk who ingested it died. "This therefore was the reason of this Mineral being call'd Antimony," Pomet wrote, "as being destructive of the Monks." (In a less fatal episode, a nineteenth-century doctor and his friends consumed fifteen milligrams of tellurium each: they had garlic breath for eight months.)

The names of the elements have long been a source of contention and incomprehension. Hydrogen, Wothers points out, is Greek for "water-former," while oxygen is Greek for "acid-former"; in fact, it's hydrogen that bonds together with other elements to make acids and oxygen that bonds hydrogen to make water. "Aluminium," Charles Dickens wrote, in 1856, is "a fossilized part of Latin speech, about as suited to the mouths of the populace as an ichthyosauros cutlet or a dinornis marrow-bone." (It has its root in the Latin for "bitter salt," after the clay from which the once-precious metal was derived; Dickens's suggestions—"loam-silver" and "glebe-gold"—weren't much better.) The French chemist Marguerite Perey, a protégée of Marie Curie, discovered an element of her own, in 1939. She wanted to call it "catium," to honor the particle's strong attraction to cathodes, devices used to send electricity through a chemical substance; Curie's daughter, Irène Joliot-Curie, worried that English speakers would associate the element with house cats. Perey, being French, decided to call it francium instead.

Many historians date the invention of the periodic table to the publication, a hundred and fifty years ago, of a textbook by the Russian chemist Dmitri I. Mendeleev. But Eric Scerri, the author of "[The Periodic Table: Its Story and Its Significance](#)" (Oxford) and a philosopher of chemistry at U.C.L.A.—he studies the history of questions such as "What is an element, really?"—bristles at the notion that Mendeleev revolutionized science when he brought chemical periodicity into clear relief. Periodicity—the idea that larger atoms chime with smaller atoms in a regular way, like notes on a keyboard—didn't emerge

as a bolt from the blue, Scerri argues. It came into focus through the work of a host of scientists; as it did so, ideas that by then were long disdained, such as alchemy, turned out to be right in some respects, and essentially wrong ideas, such as the irreducibility of the elements, turned out to be productive ways of thinking, anyway. Some of the eighteenth- and nineteenth-century chemists who began to notice patterns among certain elements were actually retracing the paths of ancient Greek atomists such as Democritus and Leucippus, who, in the fifth century B.C., had argued that invisible and indivisible particles made up everything we could see and touch. The atomists believed that those particles were myriad in shape and size, and that their perceptible properties came from the structures they formed when they hooked together.

By the Middle Ages, atomistic ideas had been mostly eclipsed by Aristotle's theory that four principal elements—fire, earth, water, and air—combined to form the various objects in the universe. But atomism never went away completely. Renaissance scholars believed in a wide variety of elemental schemes. Wothers's book reprints some of the diagrams that mixed these ideas in advance of the periodic table: a seventeenth-century engraving of the "seven metals" shows seven Roman gods brandishing ancient chemical symbols (the deities reminded viewers that iron was from Mars and copper from Venus); another shows the seven metals and Aristotle's four elements in a triangular arrangement. Ringing the whole diagram is a Latin motto: "Although I am invisible, I am nonetheless the father and mother of all visible earthly bodies."

You didn't have to be a scholar, of course, to believe in a world made up of more than four elements. Seventeenth-century miners, Wothers writes, distinguished between different kinds of air: they called the lighter air that swirled at the top of caves "fire-damp," because it easily burst into flames, and the heavy clouds that hung near the ground "choke-damp," because they made it hard to breathe. In the eighteenth century, locals dubbed a cave near Naples the *Grotta del Cane*: dogs who wandered into the cave, unable to raise their heads above the gas seeping out of the Earth, soon began to choke to death; once returned to the open air, the animals would revive.

As these observations proliferated, so did the conviction that there must be many different elements. By the end of the eighteenth century, scientists, combining substances, began realizing that certain materials always reacted in the same proportions, which suggested that they had different underlying masses. (It always seemed to take a little more ammonia than it did magnesia to neutralize the same amount of sulfuric acid.) In 1803, the English scientist John Dalton proposed that atoms were at work in such reactions; he encouraged his peers to help him determine how much these invisible entities weighed. What Scerri calls a "craze for searching for numerical regularities" began. Chemists soon noticed patterns when they grouped elements into sets of three by atomic weight. (Lithium, sodium, and potassium, for example, all fizz or explode in water; it turned out that sodium's atomic weight is the average of lithium's and potassium's.) Such experiments offered glimpses of an order within the elemental universe. But the work was frustrating. In 1836, the chemist Jean Baptiste André Dumas, a disciple of Dalton, threw up his hands in despair. "What remains of the ambitious excursion we allowed ourselves into the domain of atoms?" he wrote. "If I were master I would erase the word 'atom' from the science."

Other chemists pressed on. As atomic weights grew more accurate, more patterns emerged. In 1864, the German chemist Julius Lothar Meyer published a table of twenty-eight elements. Meyer's elements, arranged mostly by increasing weight, were also lined up according to their common chemical properties, which repeated at regular intervals. Five years later, Mendeleev published his own periodic table, which steadily evolved into the version we use today. Like Meyer, Mendeleev had organized his particles into a rough grid, its rows containing elements with similar properties. But he also garnished his table with many tempting question marks and empty spaces, and made explicit elemental prophecies. Mendeleev accurately predicted the existence of then-undiscovered elements, such as gallium and germanium, and foretold their interactions with other elements.

Mendeleev's predictions were wrong as often as they were right. But, Scerri explains, the Russian chemist was a master storyteller and, compared to Meyer and other competitors, a more effective evangelist for the periodic system. Mendeleev took every opportunity to argue, at times heedlessly, that the characteristics of the elements repeat in an orderly and predictable way. He was both indefatigable and inflexible, at least until the tide of scientific opinion turned against him. In the late eighteen-fifties, scientists found that the elemental makeup of a given substance could be deduced from the light that it gave off when set ablaze; in 1868, a French astronomer, Jules Janssen, used the technique to discover helium (element No. 2) on the surface of the sun, during a total solar eclipse. At first, Mendeleev argued that helium could not exist; it had no place on the periodic table. But, around the turn of the twentieth century, after the other noble gases had been discovered and shown to share properties with helium, other scientists made a column just for them, and Mendeleev fell in line. (The column runs along the right, with helium poking out on top.)

The table's ability to adapt has helped it endure. In the twentieth century, scientists realized that periodicity wasn't determined by atomic weight; instead, what mattered was the number of protons that each atom contained in its nucleus. But this discovery didn't break the table, either; after a few reshufflings, it became more accurate. Over the past century and a half, our ideas about the universe have changed drastically. But the basic format of the periodic table has endured.

That's not to say that no one has tried to revise it: Scerri notes that, since the eighteen-sixties, more than a thousand alternative periodic tables have been proposed, often with the aim of capturing periodic patterns left out of the original. They include Fernando Dufour's three-dimensional Christmas tree, from 1990; Theodor Benfey's spiral pattern, resembling a duck's head, from 1964; and William Crookes's nineteenth-century pretzel-shaped sculpture, which now sits at the Science Museum, in London. This last model placed uranium at its base, under the assumption that chemistry would never encounter a bigger atom. But the elemental ceiling has continued to rise. The stories of the thirty or so elements discovered in the past

century—some of which Mendeleev and Meyer couldn't have imagined—constitute the bulk of "[Superheavy: Making and Breaking the Periodic Table](#)" (Bloomsbury), by the science journalist Kit Chapman.

Early element hunters had used fire to distill their elements, or else mixed minerals with boiling acid. Those techniques were replaced, in the twentieth century, by technologies that used electricity to shake atoms into pieces. Scientists, moreover, realized that atoms have structures, made up of protons, neutrons, and electrons; those structures can fall apart or get bigger. These developments fundamentally changed our relationship to matter. Discovering an element used to be like finding Dr. Livingstone in East Africa: you knew he was there somewhere. Now the line between discovering and creating blurred. Elements made in the lab might exist nowhere else.

The modern element-hunting era began in the nineteen-thirties, when the physicist Ernest Lawrence directed scientists at the University of California, Berkeley, to develop a series of devices, called cyclotrons, that use electricity to blast protons into foil targets installed inside metal chambers. Researchers soon found that some of the supercharged nuclear particles would glom on to the atoms in the targets and create bigger, heavier elements. The particles were infinitesimally small and their chances of collision were negligible. "It is like shooting birds in the dark in a country where there are only a few birds," Albert Einstein said, in 1934. Still, Lawrence's cyclotrons allowed element hunters to take trillions of shots, and by 1937 one of his devices had created technetium (element No. 43), an atom predicted by Mendeleev. Like all elements first born in cyclotrons, technetium was radioactive. Lawrence won a Nobel Prize for his invention in 1939; that same year, Einstein told President Roosevelt to get working on a nuclear weapon.

Such bombs, when they detonated, further filled out the periodic table. Starting in 1952, the United States blew up hydrogen bombs around the Marshall Islands. Researchers then sent F-84 fighter pilots flying into the explosions. (The fireballs, Chapman notes, were hot enough to "mimic the intense furnace of the Sun.") Scientists had outfitted the wingtips of the F-84s with filters capable of picking up atoms forged in the blast. Bursting through the stems of the mushroom clouds, trying to keep their planes from rattling apart, the pilots, Chapman writes, collected "elements usually only present in merging neutron stars." (One pilot, Jimmy Robinson, escaped from the nuclear dust storm to find that his engines had stalled; he died in an attempted water landing.) Later, in a Berkeley laboratory, the physicist Glenn Seaborg and his colleagues detected two hundred atoms of what would become element No. 99 in a filter pulled from one of the planes. It took years of wrangling to declassify their discovery, but the Berkeley scientists publicly described the element in 1954. They drank "an abundance of cocktails" and eventually named their new particle einsteinium, after the man who had suggested the bomb.

Even in laboratory settings, the hunt for new elements could be dangerous. In 1959, Al Ghiorso, a Berkeley physicist with nerves of steel—he was known to fill tennis balls with radioactive material and bat them around—was looking for element No. 102. One day, around lunchtime, he overloaded a particle accelerator with helium while bombarding a filter made of curium; the helium swelled the curium filter, Chapman writes, until it popped like "a balloon filled with radioactive glitter." Ghiorso ducked beneath the cloud, and the building was evacuated. And yet, for his trouble, Ghiorso may not have been the first to discover the element. A Swedish team, using rudimentary equipment, claimed to have found it first; they wanted to call it nobelium, after the Swedish inventor of dynamite. Soviet scientists, meanwhile, questioned the results coming from both Stockholm and Berkeley. The naming of elements No. 100 and No. 101, fermium and mendelevium, had caused little stir, but that relative calm soon shattered. In a period now called the "transfermium wars," the cycle of discovery and doubt became the leitmotif of Cold War element research. (In the end, the International Union of Pure and Applied Chemistry credited the Soviets with the discovery, while allowing the name "nobelium" to stand.) By 1970, there were at least two major variations on the periodic table. Americans named element No. 104 after Ernest Rutherford, the father of nuclear science; the Soviets named it after Igor Kurchatov, the father of Russian nukes.

As the transfermium wars continued, an irony emerged: atomic researchers were chasing immortality through the discovery of elements that quickly blinked out of existence. The "superheavy" particles took massive amounts of energy to produce; they then tended to fall apart, turning into lighter elements, often within nanoseconds. Scientists in the United States and the Soviet Union began trying to figure out how to make them last longer. Experimenting with elements created by the Manhattan Project, researchers realized that they could create two different versions, or isotopes, of promethium, the sixty-first atom on the periodic table. One promethium isotope, with eighty-eight neutrons, has a half-life of a few days; the other, with eighty-six neutrons, has a half-life of a few years. Apparently, the right, "magic" number of neutrons and protons could hold the hypercharged whole of a superheavy element together. Researchers began to wonder if these longer-lasting giant atoms might occur in nature. Chapman presents one scientist's sketch, from 1978, titled "Map of the Isotopes." It shows a "sea of instability," into which a peninsula extends. On the end of the peninsula, a small figure rests within a giant slingshot; the slingshot is aimed toward a "Magic Island," guarded by a formidable bird of "nuclear viscosity," with outspread wings.

The dream of a magical island of stable atoms, hidden many rows down the periodic table, set off what Chapman calls a superheavy "gold rush." Instead of creating superheavy elements, in particle accelerators, researchers began looking for them out in the world. One theory was that, if stable superheavy elements existed, they would be easier to detect farther away from the surface of the Earth, which is bombarded by radioactive cosmic rays that can overwhelm sensitive detectors. Another theory was that superheavy elements (or evidence of them) might be found inside materials made of elements in the same periodic column. Scientists travelled deep into the ocean, dug around salt mines, scrutinized gold nuggets, sent up high-altitude observational balloons, hiked through subway tunnels, scooped brine from the Caspian Sea, picked at sixty-million-year-old shark teeth, and entered cathedrals to analyze stained-glass windows. (The lead lining, they hoped, might have preserved evidence of some ancient nuclear reaction.) But, after two decades of searching, no new superheavy elements were discovered in nature. It seemed to be particle accelerators or nothing.

In recent years, instead of discovering an island of stability, scientists may have nearly done the opposite: they've created superheavy elements that threaten to break the periodic table. In 1998, Russian scientists created a new element that blinked out of existence after little more than a second. The head Russian element hunter, Yuri Oganessian, named it after his late mentor, Georgy Flerov. In 2016, Oganessian got his name on an atom, too. His element, which is currently the last one on the periodic table, was likewise a blip in the machine. Chapman believes that elements like flerovium and oganesson (elements No. 114 and No. 118, respectively) might spell the "end of chemistry as we know it." Oganesson sits at the bottom of the column with the noble gases, but a paper from 2017 suggests that it may not belong there: the velocities of its supercharged electrons likely approach the speed of light, and so the element may not act like the gases with which it's grouped. Instead, oganesson and its neighbors might follow the rules of relativity; time and space might appear to bend inside them, and their properties could follow suit.

Scerri doesn't believe the periodic table is seriously threatened by elements like oganesson; he points out that some of the electrons in gold atoms spin at velocities that approach light speed, too. It could be that even relativity fits a pattern—"a further testament," he writes, "to the underlying fundamental nature of the periodic law." (Copernicium, No. 112, is a row below gold, and also seems to incorporate relativistic effects.) And yet Scerri argues that such elements destabilize the periodic table in a different way. The table was originally imagined as describing the building blocks of nature. But, as element hunters have become element makers, the table's meaning has changed. It now describes what is possible, as well as what merely exists.

Even if there is an island of atomic stability, the superheavy elements that live on it are likely to be exceedingly rare. Hydrogen atoms burning up in a single star only tend to get as heavy as iron (element No. 26 of the hundred and seventy-two or hundred and seventy-three possible elements some scientists conjecture could exist). Astrophysicists believe that the bigger atoms which arise in collapsing stars might, after travelling vast distances in space, land in the cauldrons of other stars and keep growing. But the Earth is four and a half billion years old—much older than the half-life of even the most stable predicted superheavy elements—and few traces of them have been found here. (Because superheavy elements are likely to decay quickly, element hunters examine meteorites, which may have issued from more recent stellar explosions.) In the next few years, atomic scientists with particle accelerators will easily create elements No. 119 and No. 120. Those elements may never be seen outside of the lab.

Elemental fever seems to have cooled off in the United States, but it continues to simmer elsewhere. Japan discovered its first element, nihonium, No. 113, in 2004, and Chapman reports that Japanese children read mangas dramatizing the work of the country's top nuclear physicist, Kosuke Morita. When nihonium was officially added to the periodic table, in 2016, Crown Prince Naruhito was deeply moved: at a special ceremony, he reminisced about copying the periodic table by hand as a boy. Meanwhile, in Geneva, scientists at *CERN* have broadened the hunt to other parts of the cosmos. "Some people believe that there could be different forms of dark matter," Ying Wun Yvonne Ng, a particle-physics researcher, told me. "Who knows," she said. "It could potentially fill up a much larger periodic table."

Technetium, the first man-made element, is still used in cancer treatments around the world. In theory, newer elements could be similarly useful: according to Chapman, scientists have speculated that a pea-size sample of flerovium "could power a city," if it could be stabilized. In truth, though, it seems that obsessive element hunters are in it for abstract reasons that transcend even scientific glory. In "Superheavy," Chapman visits Oganessian at his lab in Russia to ask him why he's still hunting—especially now that he has an element that bears his name. "If you have a device that can do this," Oganessian replies, "why not?" You build the machine to find the atoms; you make the atoms because you have the machine. "This is like Pandora's box," Oganessian says, patting a component of a cyclotron that's currently under construction. "A new facility. A new accelerator." Keep finding elements, and the story never has to end.

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**March 10 - 15, 2020**

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