THE VORTEX

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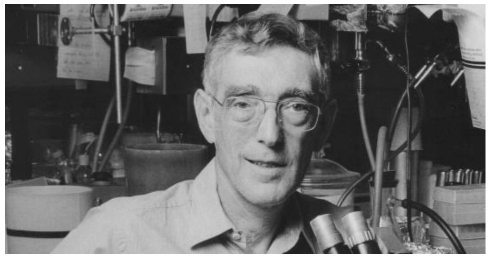

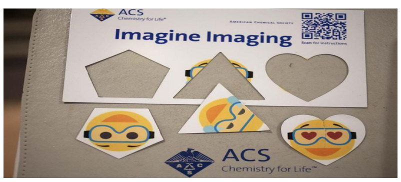

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Cover Image Credits:

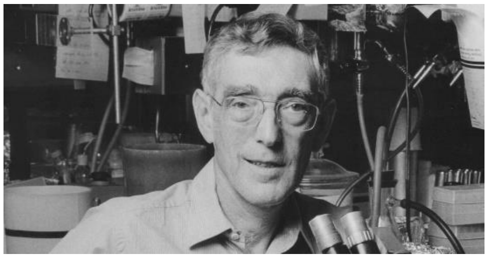
Center Top: Bruce Ames, NYT
Middle Left: Alex Madonik

Passing of Bruce Ames

Here is a note that was passed to me.

Bruce Ames died earlier this month (at age 95) but I just read about his death today. You can find his obituary in the NY Times at the link below.

https://www.nytimes.com/2024/10/21/health/bruce-ames-dead.html



Bruce Ames, 95, Dies; Biochemist Discovered Test for Toxic Chemicals
The Ames Test offered a fast and inexpensive way to identify carcinogens, leading to the banning of chemicals linked to cancer and birth defects.
www.nytimes.com

Review of Talk on “Designing Tomorrow” by Dr. Julie Beth Zimmerman, presented at WCC Meeting on 9/14/24

By Abigail O. Gyamfi

Part I. Background

Dr. Julie Zimmerman is an internationally recognized engineer whose work is focused on advancing innovations in sustainable technologies. She has a wealth of experience, from working at the U.S. Environmental Protection Agency (EPA), to serving as the Editor in Chief for a leading journal, Environmental Science and Technology. She serves in different roles in many departments and schools at Yale University. She is a professor jointly appointed to the Chemical & Environmental Engineering Department of the School of Engineering and Applied Sciences and the School of Forestry and Environmental Studies. She earned a B.S. in civil environmental engineering at the University of Virginia, and a dual Ph.D. in environmental and water resources engineering and resource policy and behavior from the University of Michigan. Five years ago, she testified before the U.S. House of Representatives Committee on Science, Space, & Technology on the “Sustainable Chemistry Research and Development Act of 2019.” Her research interests span a wide range of environmental science and technology topics, including water treatment and the environmental implications and applications of nanotechnology. She has been recognized with multiple awards including the ***Ackerman Award for Teaching and Mentoring***, Yale School of Engineering and Applied Sciences, 2020.

The CalACS was incredibly fortunate to have a talk, “Designing Tomorrow” from Dr. Julie Zimmerman who is the first engineer invited to speak at the WCC Meeting. Her talk focused on sustainability. She currently collects all the environmental work (climate change and sustainability) that is happening on campus and makes sure the community thinks about these problems in an interdisciplinary way. She emphasized Yale University’s commitment to sustainability, generating innovative ideas in support of a thriving planet through **Yale *Planetary Solutions***. She highlighted the framework they use and much of this is in collaboration with *Prof. Paul Anastas* (Teresa and H. John Heinz III Professor in the Practice of Chemistry for the Environment), who runs the Center for Green Chemistry and Green Engineering at Yale.

Yale is committed to providing knowledge, creating impact through its innovative sustainability projects, spinning out technology, empowering students, and the entire university community to drive a positive environmental change. She emphasized what environmental experts spend their time, energy, and resources on, highlighting that a substantial amount of time is devoted to understanding problems particularly within the environmental space. However, comparatively, far fewer resources, whether in terms of time or funding, are directed towards developing and implementing effective solutions. She and other experts in green chemistry and sustainability are eager to see this balance shift soon.

Part II. Engineering solutions in a world full of absurd practices

Dr. Zimmerman advocates for a more solution-oriented approach, emphasizing the urgency to direct our efforts and focus on how we can make things better. She discussed the absurdity of certain past norms and explained these concepts to students and newcomers by encouraging them to reflect on how society views past generations. She pointed out that we often find it absurd that certain practices were once considered socially acceptable or normal. For instance, it is now unfathomable that women in the United States were once denied the right to vote and this was the law of the land at the time. Similarly, past advertisements promoted smoking as a healthy choice. We show by these examples how societal perspectives and awareness have changed dramatically over time. She also addressed a current, important absurdity. The United States consumes 767 billion cubic meters of natural gas, and flares 20% that much annually. This prompts us to consider how future generations will look back on us and ask important questions such as, "How did they tolerate that? Why was that okay?" We invest money and resources to extract natural gas from the earth's crust and then we just burn 20% of it at the source. This is absurd and it is something we should reflect on, with a similar eye on how we look back on other absurdities of the past.

Globally, the fossil fuel industry benefits from subsidies totaling $11 million per minute; $1m is explicit and $10m is implicit (published by the International Monetary Fund, IMF, https://www.projectcensored.org/1-fossil-fuel-industry-subsidized-at-rate-of-11-million-per-minute/). She provided this context to highlight the challenges faced by startups, and new chemistry technologies trying to compete with the petroleum industry. Startups and these emerging technologies do not receive similar levels of subsidies and so the market is quite lopsided. This disparity places a huge burden on these startups to launch to be price competitive and be greener and safer. It is important that we think about what this market looks like.

It was interesting to learn that in the United States, 2.3 billion gallons of drinking water is flushed per day, and that is enough to meet the drinking demands of the entire African continent. She pointed out that we use chlorine gas to purify drinking water, flush down the toilet so we could treat it again. This practice is quite absurd. Future generations will find it shocking.

Even today, 40% of global energy production is from coal, with 40% of that energy being used for fertilizer production through the Haber-Bosch process. It is quite alarming that we generate such high levels of CO_2 and greenhouse gas emissions just to produce fertilizer.

The Ellen MacArthur Foundation conducted an analysis which predicts that by 2050, there will be a little over one mega ton of fish, with an equivalent amount of plastic in the ocean. It is worrying to think that the materials we continue to release into the ocean are accumulating to match the amount of fish present. This raises the question of what future generations will think of our actions.

Considering China, in terms of development, it is remarkable that they have built thirty equivalent New York Cities over the past decade. Cement production contributes about 8% of all greenhouse gas emissions. The scale at which we are seeing change happen and the technologies we are relying on to get there are quite problematic. She envisions that future generations will wonder why we did it that way.

She shared a study known as *body burden*, highlighting a 2015 report by the Center of Disease Control that found 287 different synthetic chemicals in the umbilical cords of newborns. Of these chemicals, 180 are known carcinogens, 208 are suspected developmental toxins and several had been banned since the 1970s. This implies that these newborn babies are born with 287 chemicals already present in their bodies even before they are exposed to the environment. It is a global concern that these are all unintended consequences from our lifestyles, societal structures, businesses, private goods, and public distribution of harm, etc. For instance, the issue of food versus fuel consumption, using crops to produce biofuels (example, corn for ethanol) can lead to unintended consequences, such as food shortages and rising prices.

Historically, chlorine gas was used as a chemical warfare agent during World War I. Chlorine is also used to treat drinking water. However, this process creates disinfection by products that are known to be carcinogens. While it is crucial to provide clean and safe drinking water to our population, the current method uses toxic chemicals and generates toxic waste. We have awareness to try to do the right thing, but are we doing the right things, wrong? She cited several other examples, such as spraying pesticides and fertilizers on agricultural fields to grow food, which then runoff into water sources. These happen because we are so interested and focused on performance, functional use and economic value of chemicals, materials, or energy we produce that we do not consider the unintended consequences. A central theme of her talk was problem formulation and the importance of developing solutions that meet societal needs in ways that are conducive to life today, and in the future! This requires changing the inherent nature of materials and energy sources. She shared several key solutions that are renewable, not depleting, healthful instead of toxic, and restorative rather than degrading such as:

- Provide clean water without using and generating toxic chemicals.
- Generate energy without altering the atmosphere.
- Produce goods and services without depleting finite resources and generating waste.
- Grow food without polluting our water with fertilizers and pesticides.
- Provide healthcare without harming public health.
- Be efficient without continuing to increase absolute emissions.

Part III. Conclusion

One of her favorite quotes attributed to George Bernard Shaw often quoted by Robert F. Kennedy is, "*Some see things as they are, and say why? I dream of things that never were and ask why not?".* She emphasized the importance of investigating and applying green chemistry and green engineering principles to design safer products, policy design and analysis for sustainability, and water treatment technologies for communities. This talk created an opportunity for the audience to holistically learn and engage with an outsider scientist with an environmental and chemical engineering background.

Lunch, Bocce, and Electrochemical Systems for Large-Scale Energy Storage

Alex Madonik

September was a busy month for the California Section, starting with a full day of public outreach at the Solano Stroll in Berkeley on Sunday, September 8th, continuing with the WCC Zoom presentation on sustainability by Professor Julie Zimmerman ("Designing Tomorrow") on Saturday, September 14th, and the Diversity in Science event on Saturday, September 21st, hosted by the Lawrence Hall of Science in Berkeley and featuring a film ("Surviving Voices – Quilt Panel Makers") documenting the history of the AIDS epidemic, followed by an exciting update on HIV treatment and prevention by Dr. Christoph Carter, Senior Director of Clinical Development at Gilead Sciences.

The last Saturday in September found us in Fremont, CA, where a dozen Cal ACS members and friends gathered at the Mission Peak Sportplex for networking, an excellent Mexican-themed buffet, and a talk by Dr. Nicholas Cross, postdoctoral researcher at Lawrence Livermore National Laboratory. His talk, "Electrochemical Systems for Large-Scale Energy Storage" attracted another half-dozen online viewers from across the Bay Area and as far away as Penn State University (where Dr. Cross completed his doctoral studies). He set the stage by reviewing current U.S. energy consumption (approximately 100 quadrillion BTU's in 2022). Just considering electricity generation (about 38 Quads), about 40% comes from renewable or nuclear sources (non-fossil fuel), and the challenge is to decarbonize the remaining 22 Quads by 2035 to meet U.S. commitments to reduce carbon dioxide emissions. Including transportation, manufacturing, and space heating, the long-term goal is to decarbonize 56.5 Quads of energy use. It's a huge challenge.

The growth of solar PV electrical generation has reduced the consumption of natural gas during daylight hours, but energy storage is crucial to provide power at night. Pumped hydropower is the best-established storage method, but it is restricted to specific sites and cannot be expanded. Other mechanical and thermal storage methods are still at the prototype stage. Electrochemical storage (batteries) is growing rapidly; in fact, California utilities currently have the equivalent of 10 gigawatts of battery storage, primarily lithium-ion batteries, and this capacity is projected to grow tenfold by 2050. Battery storage is already reducing the risk of blackouts in California.

Dr. Cross reviewed the principles of electrochemical energy storage, which requires a coupled pair of reversible reactions that can be used to charge and discharge a battery. The reaction pair defines the available potential, but efficient storage also requires stable materials with high conductivity and rapid ion transport. The current generation of lithium-ion batteries rely on multiple materials that face short-term or long-term supply risks, including lithium, nickel, cobalt, and graphite. Lithium-ion batteries are also susceptible to thermal runways and fires, initiated by defects, overcharging, mechanical damage, or chemical breakdown.

Could earth-abundant sodium replace lithium? The sodium ion is substantially larger, increasing weight while slowing ion transport. Nonetheless, sodium ion electrolytes have conductivity that is close to their lithium equivalents. Sodium ion anodes use graphene or amorphous carbon rather than graphite to stabilize the metal atoms. Various abundant metal oxides can be used as the cathode that accumulates sodium ions during battery discharge. These batteries resist thermal runaways and thus promise improved safety.

Solid-electrode batteries offer high power and energy density that is essential for transportation, but size and weight are not critical for grid scale energy storage. Flow batteries offer reduced cost and easy scale-up, since the electrolytes are stored in tanks that can be as large as needed. The electrolytes are pumped through electrode cells where the electrochemical reactions take place during charging or discharging. Both inorganic and organic electrolytes have been used in prototype batteries, and several types are currently in small-scale production. Most use some combination of strong acids, expensive membrane separators, and are limited to relatively low voltages to avoid electrolysis of the water in the electrolytes.

The Department of Energy has set a target of five cents per kilowatt hour, and all the technologies discussed here (except sodium ion batteries) are expected to reach this target by 2030.

Cal ACS at Science in the Park – 05 October 2024

Alex Madonik

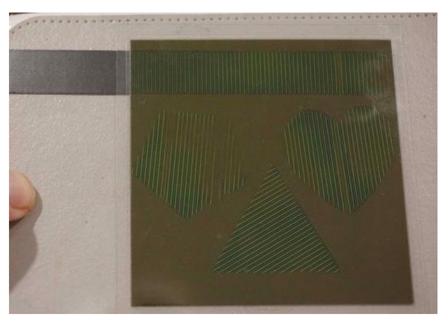
It was a great day for science outreach in Hayward, CA, as Cal ACS returned to Science in the Park. The Alameda County Board of Supervisors hosts this event every other year, and their volunteer team was ready to welcome Charlie Gluchowski and me when we arrived around 8 AM to set up. Since the festival provides canopies, tables, and chairs, we could focus on the promoting the NCW 2024 theme with fun activities on the theme, Picture Perfect Chemistry. After hanging the NCW banner behind our table, we unpacked UV-color-changing beads, cyanotype imaging paper, and ferromagnetic fluid sheets that detect magnetic fields. Our display featured Celebrating Chemistry and plenty of bling for our visitors:

Charlie and I were delighted to welcome a total of ten student volunteers from our introductory chemistry classes at Las Positas College and College of Alameda. The first four volunteers were ready when visitors started to arrive just after 9 AM, and soon they were explaining each activity to a steady stream of future scientists. Kids were happy to make UV-detecting bracelets, and we assured them that the dramatic color change of the photochromic beads in sunlight would reverse to colorless in the dark. Almost everyone tried their hands at making cyanotype images as well, using UV flashlights to illuminate Starlight® paper through stencils and film negatives, or capturing surprising shadows from familiar objects such as keys and utensils. This process requires some patience and a steady supply of AAA batteries for the UV flashlights! We already knew that it's important to protect the yellow, light-sensitive side of the paper from sunlight, which (paradoxically) bleaches the yellow iron(III) complex to colorless white.

By the time I packed up at 3 PM, the temperature was approaching 100°F; we were fortunate to be well shaded by the canopy provided by the festival, and visitors took away hundreds of Periodic Table cards and copies of Celebrating Chemistry in Spanish as well as English. We look forward to 2026!

At this event, we also introduced visitors to specially designed magnetic sheets from the ACS Store:

These magnetic sheets have lines of magnetic material running vertically, and the probe sticks to the sheets when it's oriented the same way, but not when it's oriented at some other angle.



We also used plastic cards containing a thin layer of ferromagnetic fluid to directly visualize these magnetic lines. We had fun exploring the unique patterns created on these cards by other types of magnets.

Dr. Carolyn Pearce on "Reducing Risk and Uncertainty Associated with Nuclear Waste Processing and Disposal: A Hanford Tank Waste Case Study"

Speaker for the WCC Meeting on November 2, 2024

By Kathryn Louie, Permian Basin Local Section

Dr. Carolyn Pearce directs the Pacific Northwest National Laboratory (PNNL) – led US Department of Energy (DOE) Office of Science supported Ion Dynamics in Radioactive Environments and Materials (IDREAM) Energy Frontier Research Center. She spoke about characterizing solutions and minerals relevant to radioactive waste storage and processing as well as determining reaction mechanisms and kinetics that affect radionuclide stability in waste forms and subsurface environments.

The main focus of the talk was on the Hanford site in Washington State, which produced plutonium for the United States weapons program. This site is the most contaminated nuclear site in the nation, and the largest DOE legacy waste site and the department's largest environmental clean-up activity. During weapons production, 56 million gallons of liquid radioactive/chemical waste (sludge, salt cake, and supernatant), with >170 million Curies of radioactivity and 240,000 tons of complex chemicals, was generated. This liquid waste is the primary environmental contamination risk.

A key issue of Hanford tank waste processing and disposal is that, although radionuclides such as technetium are the risk drivers, 'benign' dominant elements such as aluminum dictated the processing limits and uncertainties, given that tank waste is removed on a volume basis. The main contaminants in the waste were found to be oxides and hydroxides of aluminum. The goal of IDREAM is to understand the basic aluminum speciation change mechanisms that affect solubility, nucleation and precipitation in Hanford tank waste to accelerate safe, cost-effective, and efficient waste processing.

Once the waste has been processed, it must be demonstrated that risk driving radioactive elements will be contained in the waste form for thousands of years until they become safe. Archeological artifacts, analogous to waste form materials, i.e., glass, that have been left by our ancestors and exposed to the environment for thousands of years can be used to validate and refine predicted waste form durability. Analysis of artifacts from various archeological sites to validate long term storage of the waste are ongoing. The nuclear waste is currently intended to be processed into a glass form for stabilization and to allow its radioactivity to safely dissipate over hundreds to thousands of years. Uncertainty associated with nuclear waste processing and disposal can be mitigated by: (i) characterizing waste chemistry; and (ii) understanding waste form behavior in the environment.