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Thursday, December 7, 2023, 6:00 PM

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“Nuclear Power: An Introduction”

The Sanctuary Restaurant, DoubleTree Hilton Hotel by Rockside Road

6200 Quarry Lane, Independence, OH 44131, 216-901-7852

ABSTRACT: As the world and the country try to go green, many are taking a fresh look at nuclear power as a non-emitting power source. This lecture will go into the basics of the nuclear reaction and how this reaction creates heat to make electricity. How is power generated from a nuclear reaction? What is the process of splitting the atom. Why is the nuclear reaction different than conventional power generation? What is the impact that radiation has on living tissue? Along the way, we will discuss the basic terminology and physics behind this reaction. There will be a discussion on why the nuclear reactors are different than other electrical generation sources. Finally, there will be a comparison of health based risked associated with radiation exposure. The lecture will end with an open forum for questions. Please tune in if you are interested in the physics of nuclear power generation.

BIOGRAPHIES:

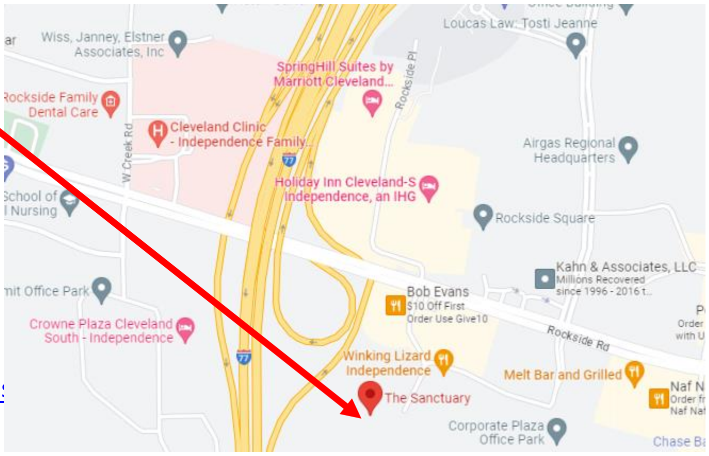
Andrew Ohrablo is the Maintenance Engineering Supervisor at Perry Nuclear Power Plant with over 30 years of study and experience in the nuclear power field. Mr. Ohrablo started his nuclear career with the United States Navy in 1987. After training as a nuclear electrician, he was stationed on the USS Enterprise and served till 1993. Following his time in the Navy, Mr. Ohrablo returned to school at The Ohio State University. He transferred to the University of Wisconsin at Madison and received his Bachelor of Science Degree in Nuclear Engineering in 1998. Mr. Ohrablo’s thesis was on the design of a Liquid Sodium Cooled Fast Breeder Reactor. He then began a career in the civilian nuclear power field as a Shift Technical Engineer at Cooper Nuclear Station in Brownville, Nebraska. In 2008 he completed Senior Reactor Operator License Class and received his Nuclear Regulatory License effective March 27th, 2008. Senior Reactor Operator License Class is a 15 to 18-month instruction course that goes over the design, operation and accident response for a specific nuclear power plant. In 2014 he returned home to Ohio to work at Perry Nuclear Power Plant as a Work Week Manager and is now the Maintenance Electrical Engineer and Maintenance Engineering Supervisor at Perry Nuclear Power Plant. Mr. Ohrablo is responsible for all of the large electrical components. These components include motors, generators and transformers. He is currently the lead problem solver for all complex troubleshooting efforts that occur at the plant.

Mr. Ohrablo is looking forward to an evening of discussion with AIChE.

For those attending this event, a Professional Development Hour Certificate (1 PDH) will be sent to you in the following days by Joe Yurko.

Meeting Location:
6200 Quarry Lane
Independence, OH 44131
216-901-7852

The Sanctuary Restaurant *(see map below)*
6:00 – 7:00 pm: Social Gathering
7:00 – 8:00 pm: Dinner
8:00 – 9:00 pm: Presentation with Q & A



Dinner: Non-Students: All ordering from menu
Students: $5 each

Menu:
http://places.singleplatform.com/shulas-steak-hou

RSVP Required with Joseph Yurko and AIChE at: yurkojoe5@gmail.com

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Chem-E-Car in the Spotlight – 2023 Competitors, Part 1

Chem-E-Car in the Spotlight – 2023 Competitors, Part 2

The series 1 & 2: Chem-E-Car in the Spotlight – 2023

Thirty teams will participate in the 2023 Annual Chem-E-Car Competition® in Orlando on Sunday, November 5 from 12:30 – 4:00pm EST. Learn more about this year's competitors, the award, and this year's Annual Student Conference.

All teams were asked to provide a video spotlighting their car, school, and team. These videos will be played before each competitor's run, but you can enjoy them in this ChEnected series, which will be updated with new posts from now until the competition. Videos will be posted in the order we received them.

Check out the first set of submitted videos

After watching the videos below, be sure to share them with the hashtags #AIChEASC and #ChemECar.

https://www.aiche.org/chenected/2023/10/chem-e-car-spotlight-2023-competitors-part-1

ACS Local Section
Cleveland

NATIONAL CHEMISTRY WEEK

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Joseph Yurko, PE (He/Him) • You
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I was fortunate to facilitate the American Chemical Society's National Chemistry Week event at the Cuyahoga County Public Library Strongsville Branch. On Saturday Valerie Congdon (Co-Facilitator), Tim Protiva (CCPL Strongsville Branch Youth Services Supervisor), myself and over a dozen enthusiastic elementary school students in grades 2-6 celebrated this very successful event. Our NCW theme this year was "The Healing Power of Chemistry" with six engaging experiments for student enjoyment.

ASM Joint Meeting: Monday, October 30, 2023, 5:30 PM

Cleveland Chapter

ASM INTERNATIONAL

Heat Treater's Night 2023

"The future of gas combustion – Hydrogen and its effect on the heating of metals"

By: Justin Dzik, P.E. Director of Innovation & Business Development at FIVES North American Combustion, Inc.

(Left) 3 CSU AIChE Student Chapter Members view hydrogen burner flame demonstration.

ARTICLE, SEE Summer 2023 ISSUE

Future Focused, Ethics; National Society of Professional Engineers, PM Magazine, Quarterly magazine,
https://www.nspe.org/resources/pe-magazine/summer-2023/paving-the-way-the-future-women-engineering

BY: Julie Hawkins, P.E.

Paving the Way for the Future of Women in Engineering

I recently presented at NSPECon23 about embracing diversity, equity, and inclusion (DEI), specifically as it relates to women in engineering. Professionals from all over the country realize the importance of trying to increase the number of women engineers in the workforce. I enjoyed the collaboration and discussion that happened after my presentation. It made me realize that this is an important topic that will continue to be a key issue as we navigate the future landscape of the engineering field, with DEI as a bigger focus than ever before. As we look towards the future, promoting women in engineering is not just about closing gender gaps; it's about harnessing a wealth of untapped talent, perspectives, and ideas that can reshape the industry for the better.

Breaking Barriers and Challenging Stereotypes

Historically, engineering has been a male-dominated field. However, the engineering field is changing as more women enter the profession, shifting the way things were done before and challenging old ways of thinking. The places where we work and places where we learn are making conscious efforts to create an environment where women feel empowered to pursue engineering careers.

However, if you look at employee retention, there is still a long way to go. Roughly 20% of women end up leaving the workforce between years five and 10. Is it because they feel disconnected from their colleagues who are mostly men? Is it because they don't see themselves represented in leadership positions? Is it because they didn't have a mentor to encourage them and help them through their unique career challenges? Or something else?

Organizations should identify and evaluate existing barriers that could make it difficult for women to successfully stay in the workforce. Promoting flexible hours and hybrid work options support women in balancing careers and family through various stages of their lives. Such approaches offer autonomy, aiding women in aligning work with family needs.

This flexibility could result in increased retention, allowing women the opportunity to move up in their organizations, gain representation in leadership roles, and foster an inclusive workplace. Prioritizing flexibility signals commitment to employees' diverse needs, bolstering DEI efforts. Empowering women enriches workplace diversity and reinforces equity.

The US Supreme Court decision in June 2023 concerning race-conscious admissions policies at Harvard University and the University of North Carolina may pose future challenges to workplace diversity initiatives. Although the court decision is about race, affirmative action encompasses race and gender. With more engineering jobs than engineering graduates to fill them, this decision could hurt our field….

ARTICLE, SEE Summer 2023 ISSUE

Future Focused, Ethics; National Society of Professional Engineers, PM Magazine, Quarterly magazine, https://www.nspe.org/resources/pe-magazine/summer-2023/the-ethics-billing-services

BY: Harry E. Hughes, P.E.

The Ethics of Billing for Services

Can a lump sum contract for professional engineering services pose an ethics violation?

Harry E. Hughes, P.E., submitted the winning entry in the 2023 NSPE Milton F. Lunch Ethics Contest. Hughes is the owner of Owl Creek Engineering LLC in Thermopolis, Wyoming. His winning entry addressed the ethics of billing for forensic investigations.

The Milton F. Lunch Ethics Contest provides an opportunity for NSPE members to put their ethics knowledge to the test on topics that present ethical challenges such as artificial intelligence, climate change, and the industrial exemption. Hughes received $2,000 and a certificate.

Facts

Engineer A, a forensic engineer, is hired by Client H to analyze the collapse of a deck. The contract specified hourly billing. Engineer A inspects the collapse, collects the appropriate data, completes the analysis, prepares a report, and bills Client H. A month later, Engineer A is hired by Client F to analyze the collapse of a second deck. Again, Engineer A inspects the collapse and collects the appropriate data. Engineer A quickly realizes that the two collapses are almost identical. Engineer A presents a lump sum contract for the same amount as the invoice to Client H. Engineer A edits the previous, Client H report, changing names, dates, measurements, etc., and finalizes the second, Client F report in less than an hour. Engineer A believes that the lump sum amount is appropriate as a billing for the value of the report, regardless of the time spent.

Question

Was Engineer A's lump sum contract with Client F ethical?

NSPE Code of Ethics References

Preamble: "…Accordingly, the services provided by engineers require honesty, impartiality, fairness, and equity, and must be dedicated to the protection of the public health, safety, and welfare…"

ARTICLE, SEE July/August 2023, ISSUE Volume 43, Number 4

Women in Pharma Editorial Insights; Pharmaceutical Engineering, International Society for Pharmaceutical Engineers (ISPE), https://ispe.org/pharmaceutical-engineering/july-august-2023/women-pharmar-editorial-can-communication

BY: Janette Buechler, Executive Director Marketing & Sales, Pharmatech Associates

Message from Women in Pharma

Can Communication in a Multigenerational Environment Be Inclusive?

The multigenerational environment we work in poses unique challenges that make effective communication skills as essential today as they have ever been.

Due to the complexity of a distributed and multigenerational workforce, myths and stereotypes have arisen around how different generations communicate. But these stereotypes are largely unfounded and can cause friction as we try to bridge the gap between different communication styles. In this article, I debunk some of the most common myths associated with how different generations communicate and collaborate in the workplace.

MYTH 1: MILLENNIALS (1981-1996 BIRTHS) ONLY COMMUNICATE USING TECHNOLOGY

One of the most common myths about millennials is that they only communicate through technology. While it is true that millennials have grown up in a world where technology is a mainstay of communication, they often participate in face-to-face interactions. A report in the Denver Business Journal found that millennials prefer face-to-face communication when collaborating with colleagues.[1]

MYTH 2: BABY BOOMERS (1946-1964 BIRTHS) DON'T WANT TO LEARN NEW SKILLS

Another common myth is that baby boomers prefer to stick to long-established methods of communication. Although there may be a comfort level with familiar tools and techniques, they still value education. According to an AARP survey, 74% of older workers said the opportunity to learn something new is critical to their view of the ideal job. An article in Forbes noted that employee training programs tend to ignore experienced workers despite their desire to learn.[2] Which raises the question: Are employers missing an opportunity?

MYTH 3: GENERATION X (1965-1980 BIRTHS) ARE THE FORGOTTEN GENERATION

Pew Research calls Generation X the forgotten generation.[3] Why? Perhaps because they are a small group between the larger baby boomer and millennial generations. However, this does not mean they are less important in the workplace or less capable of effective communication and collaboration. They are also referred to as the "most connected" generation, bridging the gap between the generations older and younger than them. Gen Xers can understand both long-established and modern communication methods and are fluent in both.

MYTH 4: GENERATION Z (1997-2013) AVOIDS FACE-TO-FACE INTERACTION

Generation Z, the youngest generation in the workplace, is often stereotyped as being glued to their smartphones and only communicating through social media. Although it is true that Generation Z is consumed with handheld technology, they thrive on human interaction while keeping up with their friends and family online. According to a LinkedIn Learning survey, while Generation Z enjoys using technology to communicate, it's not their preferred method of communication in the workplace.[4] They also value face-to-face interactions.

MYTH 5: DIFFERENT GENERATIONS CAN'T WORK TOGETHER WELL

Perhaps the most harmful myth is that different generations cannot work together effectively due to their varied communication and styles. While each generation may have its own preferences, effective communication is ultimately about respecting each other's strengths and weaknesses. Findings suggest the differences between these groups are actually quite small. Perhaps it's not the differences between generations but the belief that they exist that influences our communication. Coming to terms with the value of different generational perspectives leads to better decision-making overall and potentially better collaboration.

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- [4] Anderson, B. M. "Boomers Can't Learn, Millennials Are Lazy, and 6 Other Myths About the Multigenerational Workforce." LinkedIn Talent Blog. 10 March 2020. https://www.linkedin.com/business/talent/blog/talent-acquisition/myths-about-multigenerational-workforce

ARTICLE, SEE August 14, 2023 ISSUE

Centennial: On the 100 Year Anniversary of Chemical & Engineering News (C&EN) weekly magazine, https://pubs.acs.org/doi/10.1021/cen-10126-cover1

BY: **Alla Katsnelson, special to C&EN**, *C&EN*, **2023**, 101 (26), pp 18–19August 14, 2023

A Century of Chemistry and of C&EN

In its inaugural issue, published Jan. 10, 1923, the magazine that would soon become *Chemical & Engineering News* told readers about several events and ideas in chemistry. Among them: the first sugar factory to use the enzyme invertase in production, the power of pancreatic gland extracts to treat diabetes, and a talk by esteemed chemical engineer John E. Teeple on research chemistry's role in US industry.

In the 100 years since our launch, we have sought to present our readers with a broad view of chemistry's many dimensions. During that time, both chemistry and the world at large have undergone countless transformations. Some changes have been technological, including discoveries that won Nobel Prizes and enabled progress on many fronts. And some have been societal, such as the growing importance of inclusivity in chemistry.

Through it all, we have always been grateful for how the chemistry community has embraced this magazine as a source of trusted news and commentary.

To mark C&EN's centennial, we asked you, our readers, to tell us what you see as the most consequential events, discoveries, and developments of the past century.

A significant number of you noted the industrialization of the Haber-Bosch process, which, in the words of one reader, "helped save millions from starvation, fueled one of the biggest population growths in the history of [humankind] and created the conditions for our modern world."

Almost as many of you remarked on polymer science, which has integrated plastics into the fabric of our lives, and on the significance of lithium-ion battery technology, which, as another reader wrote, "untethered us from power cords." The discovery of DNA's structure also stood out as a moment that paved the way for many life sciences technologies we rely on today. The discovery of penicillin and other medicinal molecules and the development of biologic drugs, such as recombinant insulin, made the cut too.

You noted the enormous importance of analytical instruments that allow scientists to observe and understand molecules at the smallest scales. You also pointed to the birth of green chemistry as a framework for reining in environmental harms and the crucial role that computers and big data now play in both research and industry.

Finally, you exhorted us to remember chemistry's missteps, even as we laud its accomplishments.

We hope you enjoy reading about a century of chemistry's milestones. Here's to the next 100 years.

By: Alla Katsnelson, Editorial lead C&EN, ACS

ARTICLE, SEE August 14, 2023 ISSUE

Agriculture: On the 100 Year Anniversary of Chemical & Engineering News (C&EN) weekly magazine, https://pubs.acs.org/doi/10.1021/cen-10126-cover2

BY: **Matt Blois**, *C&EN*, **2023**, 101 (26), pp 20–21August 14, 2023

C&EN, **2023**, 101 (26), pp 20–21 August 14

The industrialization of the Haber-Bosch process

Nitrogen fertilizer fuels climate change, pollutes drinking water—and feeds nearly half the planet

Earth is bathed in nitrogen. It makes up about 78% of the atmosphere, and it's stitched into every nucleotide, every cell, every living thing on the planet. But before humans learned to synthesize ammonia using the Haber-Bosch process, nitrogen was a major constraint on the proliferation of life.

Nearly all nitrogen in the atmosphere comes in the form of N_2, an inert molecule unsuitable for the chemistry that supports life. Living things need reactive nitrogen, which requires breaking the powerful triple bond holding dinitrogen's two atoms together.

For the first few billion years of life on Earth, there were two ways to convert the oceans of inert N_2 into life-sustaining reactive nitrogen: the massive, sudden heat of a lightning strike ripping through the atmosphere or microbes sucking in air and using an enzyme to slice dinitrogen's triple bond.

In the early 20th century, the chemist Fritz Haber created a third way. He reacted N_2 with hydrogen under intense heat and pressure in the presence of a catalyst to form ammonia. A few years after Haber patented his discovery, the BASF engineer Carl Bosch helped transform the laboratory experiment into an industrial operation. The technique was labeled the Haber-Bosch process. The International Fertilizer Association reports that it was used to make roughly 150 million metric tons of ammonia in 2021…

ARTICLE, SEE August 14, 2023 ISSUE

Polymers: On the 100 Year Anniversary of Chemical & Engineering News (C&EN) weekly magazine,
https://pubs.acs.org/doi/10.1021/cen-10126-cover3

BY: **Alex Tullo**, *C&EN*, **2023**, 101 (26), pp 22–24August 14, 2023

C&EN, **2023**, 101 (26), pp 22–24 August 14

C&EN, **2023**, 101 (26), pp 20–21 August 14

The plastics takeover

Thanks to polymer chemistry, plastics make up an essential part of nearly everything we touch. These 7 polymers are woven into the fabric of our daily lives

Polyethylene

Origin Hans von Pechmann, a chemist at the University of Tübingen, first observed polyethylene in the form of a fluffy white residue in 1898. In 1933, two chemists from Imperial Chemical Industries, Eric W. Fawcett and Reginald O. Gibson, touched off its commercial development by reacting ethylene under high pressure. The company opened the first commercial low-density polyethylene (LDPE) plant in 1939. Chemical companies soon created two other versions of the polymer: high-density polyethylene (HDPE) and linear low-density polyethylene (LLDPE).

Use Polyethylene is the highest-volume plastic and the polymer we are most likely to encounter every day, usually in the form of packaging and other single-use plastics. HDPE, stiff and opaque, is used in milk jugs and detergent containers. LLDPE and LDPE are clearer and elastic. They are often used together in flexible films, such as stand-up pouches, rice bags, and garbage bags.

Market size 116.2 million metric tons

Source: Chemical Market Analytics by OPIS, a Dow Jones company.

Did you know? In 1967, DuPont Canada introduced milk bags, made from LLDPE, in Ontario. They remain a quirk of Canadian milk commerce today.

Polypropylene

Origin J. Paul Hogan and Robert L. Banks of Phillips Petroleum first synthesized polypropylene in 1951. But it wasn't until a US court ruling more than 30 years later that they were granted recognition for it. Giulio Natta, working with Italy's Montecatini, had been widely given credit for the invention early on and is still considered instrumental in making polypropylene a practical polymer.

Use Polypropylene is strong and light, resists fatigue, and holds up to high temperatures and chemical exposure. In the supermarket, you'll find it in yogurt cups and soft-drink bottle caps, as well as potato chip bags, which are made of biaxially oriented polypropylene films. Polypropylene is also used to make automotive trim, structural brackets, and other durable goods.

Market size 82.9 million metric tons

Source: Chemical Market Analytics by OPIS, a Dow Jones company.

Did you know? Its excellent fatigue resistance makes polypropylene the favored material for living hinges— the plastic bands that connect integrated parts with different functions, like the ones that bind to the snap on top of a shampoo bottle.

Polyvinyl chloride

Origin Chemists had synthesized and known about polyvinyl chloride (PVC) as far back as the 19th century. But it was too brittle to be of practical use as a plastic. Working for BF Goodrich in the 1920s, chemist Waldo L. Semon combined PVC with additives such as dibutyl phthalate to make it pliable.

Use Creative formulation chemistry has made PVC one of the most versatile plastics. It is found in flexible products like shower curtains, rain parkas, and intravenous bags but also in rigid items like PVC pipes and vinyl records. Most PVC today is used in construction materials such as pipes, siding, windows, doors, and flooring.

Market size 47.1 million metric tons

Source: Chemical Market Analytics by OPIS, a Dow Jones company.

Did you know? About 56% of PVC's molecular weight comes from chlorine, extracted from brine via electrolysis.

Polyethylene terephthalate

Origin DuPont's Wallace H. Carothers and Julian W. Hill reported their aliphatic polyester polymers at an ACS meeting in 1931. But the resins were unstable in water and had relatively low melting points. About a decade later, influenced by this earlier work, John R. Whinfield and James T. Dickson of the Calico Printers Association reacted ethylene glycol and terephthalic acid together to create the aromatic polyester polyethylene terephthalate (PET).

Use Polyester clothing, which had its heyday in the 1970s, is made of PET. The polymer is also used in photographic film and protective and decorative films, such as Mylar. But its most recognizable use today is in beverage bottles and food containers.

Market size 94.4 million metric tons (including fibers)

Source: Chemical Market Analytics by OPIS, a Dow Jones company.

Did you know? PET has a recycling rate of 28.6% in the US, according to the National Association for PET Container Resources, making it the most recycled of the major plastics.

Nylon

Origin Wallace Carothers and research partner Julian W. Hill performed landmark work for DuPont on polyesters and polyamides in the 1930s. Of the polymers they created, one made by reacting adipic acid and hexamethylenediamine stood out as especially promising. In 1938, DuPont introduced nylon 6,6 commercially, and IG Farben chemist Paul Schlack first made nylon 6 from caprolactam.

Use Nylon makes for a very durable fiber. It was quickly taken up for the manufacture of stockings and parachutes and today is found in textile goods including outdoor apparel, bags, swimwear, sleeping bags, and carpets. Because of its strength, heat resistance, and other attributes, nylon is the workhorse engineering polymer. It is widely used in automotive parts, especially in structural components found under the hood, and in other durable applications, such as housings for power tools.

Market size 8.7 million metric tons (including fibers)

Source: Chemical Market Analytics by OPIS, a Dow Jones company.

Did you know? Before introducing nylon stockings in 1940, DuPont marketed nylon for toothbrush bristles….

ARTICLE, SEE August 14, 2023 ISSUE
Biotechnology: On the 100 Year Anniversary of Chemical & Engineering News (C&EN) weekly magazine,
https://pubs.acs.org/doi/10.1021/cen-10126-cover4
BY: **Alla Katsnelson, special to C&EN**, *C&EN*, **2023**, 101 (26), pp 26–27August 14, 2023

C&EN, **2023**, 101 (26), pp 26–27 August 14,

The emergence of biologics

As the fields of genetics and molecular biology evolved over the 20th century, scientists set out to use cell and genetic engineering to create medicines. These 5 events helped lay the foundation for a new therapeutics industry

Genentech's founding is a legend in the biotechnology world: Two scientists meet at a conference in Hawaii in 1972. Over hot pastrami and corned beef sandwiches, they hatch the idea of using a DNA-cleaving enzyme to insert specific genes into bacterial plasmids. Their plan—now known as recombinant DNA technology—works, and 4 years later a venture capitalist persuades one of them to commercialize it.

The fledgling firm, widely considered the first biotech company, and the biotechs that followed quickly gained reputations as places to do paradigm-shifting research with few intellectual or financial restrictions. "There was nobody above us—no VP of research," recalls Richard Lawn, who joined Genentech as employee number 44 in 1980. In meetings, scientists sketched out their best guesses for which chunks of bacterial DNA drove gene expression or acted as stop signals. "This stuff sounds so trivial in retrospect, but nobody had done it before," Lawn says.

That first wave of activity laid the foundation for the industry's evolution. Today, there are thousands of biotech companies around the world.

Discovered in 1921, insulin quickly transformed the health of millions. But its supply was limited because it was extracted from the glands of pigs and other animals. Scientists at Genentech set out to produce it using recombinant DNA technology, and in 1978 they succeeded, by inserting the gene encoding it into the bacterium *Escherichia coli*. The US Food and Drug Administration approved the drug—called Humulin and licensed by Eli Lilly and Company—4 years later.

Chemical expertise played an underappreciated role in making Humulin commercially viable; it scaled up and industrialized the drug's production from milligram to kilogram quantities, says Richard DiMarchi, a chemist at Indiana University Bloomington who worked on Humulin's development when he started as a research scientist at Lilly in 1981. The drug's success validated the notion that recombinant therapies could be profitable.

In 1985, the FDA approved a second Genentech-made recombinant protein, a growth hormone called Protropin. It later approved Amgen's recombinant erythropoietin, called Epogen. A hormone that stimulates the growth of red blood cells, Epogen became biotechnology's first blockbuster drug.

Monoclonal antibody therapies, which stimulate the immune system by binding to specific cells or proteins, had a rocky path to success. Georges J. F. Köhler and César Milstein first produced antibodies with known specificity in 1975 (*Nature*, DOI: doi.org/10.1038/256495a0), creating so-called hybridoma cell lines that could pump out antibodies indefinitely. Within a few years, researchers grasped the technique's potential for making medicines. In 1986, the US Food and Drug Administration approved the first monoclonal antibody drug, an antibody called OKT3 that prevented the rejection of transplanted organs. But because OKT3 was made in mice, not humans, it often triggered an immune response in patients.

Eight years passed before the FDA approved the next monoclonal antibody drug, and successes slowly accrued as researchers found ways to make human versions of these molecules. Today, more than 160 monoclonal antibody therapies have been approved worldwide for a wide range of indications; over 40% target cancer (*Antibody Ther.* 2022, DOI: doi.org/10.1093/abt/tbac021).

Ask any biotechnology professional about the industry's seismic moments, and most will name the death of 18-year-old Jesse Gelsinger, a participant in a gene therapy clinical trial run by James Wilson at the University of Pennsylvania. The event sent shock waves through the biomedical research community. The US Food and Drug Administration suspended the trial and scrutinized dozens of other gene therapy trials, and the incident led regulators to revamp the ethical framework surrounding clinical trial participation.

But researchers regrouped, and within a decade they had developed and tested safer vectors made of adeno-associated viruses and lentiviruses. Those efforts are now bearing fruit. In 2017, a treatment for a genetic form of blindness became the first FDA-approved gene therapy for a genetic disease, and more than a dozen gene therapy approvals have followed. The gene-editing technology CRISPR has brought our ability to alter genes to a whole new level, making it possible not just to add working versions of faulty genes but to fix mistakes in the genome…

Alla Katsnelson is a freelance science writer and editor in Southampton, Massachusetts.

ARTICLE, SEE August 14, 2023 ISSUE

Medicinal Chemistry: On the 100 Year Anniversary of Chemical & Engineering News (C&EN) weekly magazine, https://pubs.acs.org/doi/10.1021/cen-10126-cover5

BY: **Bethany Halford** and **Alla Katsnelson,** special to C&EN, *C&EN*, **2023**, 101 (26), pp 30–31August 14, 2023

A century of medicinal molecules

Chemists' work creating lifesaving drugs lies at the heart of modern medicine. These 5 drugs have changed the practice of medicine, the science of drug discovery, and the very essence of society over the past 100 years

Penicillin

Penicillin, one of the first antibiotics, has saved millions of lives. It enabled physicians to treat simple infections that had often been fatal.

Alexander Fleming famously discovered the drug in a moldy petri dish in 1928. Eleven years later, Howard Florey and Ernst Chain at the University of Oxford set out to confirm penicillin's bacteria-killing properties in mice and to test it in people. In 1941, a police constable from the city of Oxford became the first person to be successfully treated with penicillin, though he ultimately died because supplies of the antibiotic ran out.

With World War II unfolding, British scientists reached out to US colleagues to scale up production. Penicillin was first used to treat infections in wounded Allied soldiers; the wonder drug was severely rationed for civilians. But by the mid-1940s, large-scale fermentation methods were in place at commercial production facilities.

Penicillin remains one of the most widely used antibiotics in the world, although many others have been developed. As more bacteria develop antibiotic resistance, new approaches to antibiotic discovery are urgently needed.

The birth control pill

Oral birth control is so influential that it bears the simplest of pharmaceutical nicknames: the pill. Activists Margaret Sanger and Katharine McCormick, biologist Gregory Pincus, and gynecologist John Rock are often credited with the development of hormonal birth control. But chemists made the pill a reality.

By the 1920s, scientists knew that giving reproductive hormones like progesterone to animals prevents pregnancy. But this strategy was impractical as a medicine: progesterone had to be either injected or taken orally in enormous doses.

Working for Syntex in 1951, chemists Carl Djerassi, Luis Miramontes, and George Rosenkranz synthesized norethindrone—the first progesterone analog that was effective at low doses when taken orally. A year later, Frank B. Colton, a chemist at G.D. Searle, synthesized a similar compound, norethynodrel.

The norethynodrel used in early clinical trials was contaminated with mestranol, an analog of the hormone estradiol and a by-product of norethynodrel synthesis. Pure norethynodrel turned out to induce bleeding between menstrual periods, so mestranol was added to the first oral contraceptive formulations.

The US Food and Drug Administration approved Enovid, a combination of norethynodrel and mestranol, in 1957 to treat menstrual disorders and in 1960 as an oral contraceptive—the first in the US. This year, the agency made one version of the pill available over the counter. By giving women the power of family planning, oral birth control revolutionized society.

Imatinib

Imatinib was one of the first drugs designed to counteract a specific cancer-causing mutation in a gene. Its success helped establish the age of precision medicine. First approved by the US Food and Drug Administration in 2001 and sold under the name Gleevec in the US, imatinib proved to be a highly effective treatment for chronic myeloid leukemia (CML). It raised the 5-year survival rate for people with this cancer from 30% to about 90%.

Brian Druker, at the Oregon Health and Science University, and biochemist Nicholas Lyndon, then at pharmaceutical firm Ciba-Geigy (now Novartis), invented imatinib in the late 1990s. The drug blocks the ATP-binding site of a tyrosine kinase that signals cancer cells to multiply. The kinase is produced in people with CML by a mutated gene created by a DNA swap between two chromosomes.

Drugmakers had previously shied away from blocking kinases. The body contains so many that they doubted a drug could differentiate between useful and harmful versions. But imatinib did the job. The drug is now used to treat several cancers, and there are dozens of other cancer medicines that target specific mutations or whose design was otherwise informed by genomics.

ARTICLE, SEE August 14, 2023 ISSUE

Environment: On the 100 Year Anniversary of Chemical & Engineering News (C&EN) weekly magazine, https://pubs.acs.org/doi/10.1021/cen-10126-cover6

BY: **Chris Gorski** and **Alla Katsnelson,** special to C&EN, *C&EN*, **2023**, 101 (26), pp 32–35August 14, 2023

C&EN, **2023**, 101 (26), pp 20–21 August 14

Facing chemistry's destructive side

Our drive to create, extract, and use molecules in novel ways is inextricably tied to disasters—some that erupted in just moments and others that unfolded over decades. Stemming the damage these disasters have caused to the environment and human health and preventing future crises will be key challenges in the next century.

Bhopal, 1984

An industrial accident at a Union Carbide pesticide plant in Bhopal, India, wrought death and destruction on a massive scale. A methyl isocyanate tank became dangerously hot and began leaking late on the night of Dec. 2, 1984. As pressure built up in the tank, a safety valve failed, spewing more than 40 metric tons of toxic gas into the air. At least 3,800 people died immediately. Many thousands died later, and tens or even hundreds of thousands were sickened. An estimated half-million people were exposed to the gas. People in the area continue to experience health problems, and concerns about lingering environmental effects remain. Many consider the Bhopal accident to have been the worst industrial disaster in history. "The tragedy at Bhopal still boggles the mind," C&EN editor Michael Heylin writes in 1994 in an article commemorating the disaster's 10th anniversary. The tragedy served as a wake-up call for the chemical industry, spurring the widespread adoption of new safety regulations.

DDT

The 1939 discovery that DDT was a powerful insecticide earned Paul Hermann Müller the 1948 Nobel Prize in Physiology or Medicine. Its use quickly grew worldwide because it was so effective at stopping the spread of insect-borne malaria and typhus. But the substance has a massive downside: it becomes concentrated in the food chain and endangers humans and wildlife. DDT disrupts the nervous and endocrine systems and is a likely carcinogen. Although journalists and researchers raised concerns about the chemical as early as the 1940s, Rachel Carson's landmark 1962 book, *Silent Spring*, played a key role in revealing how DDT wreaked environmental damage and endangered birds and marine life. Recent research has revealed that DDT's effects on people extend across generations, to the children and grandchildren of those exposed to the insecticide. DDT was banned in the US in 1972, and its use around the world is limited by the Stockholm Convention on Persistent Organic Pollutants, though it can still be used for malaria control.

Microplastic pollution

Plastics' convenience, low cost, and durability have made these materials ubiquitous—and disposable. Researchers estimate that most of the 8.3 billion metric tons of plastic produced to date now lies in landfills or ends up in oceans as pollution. After about 75 years of mass-producing plastics, we are awash in tiny pellets of plastic debris less than 5 mm in diameter. Scientists first observed these particles in the 1970s but did not name them microplastics until 2005. Wind and water have carried these plastic pieces to all corners of the earth—the Arctic Ocean and the Antarctic snow, the Andes Mountains, and the deserts of Iran. We consume these particles in table salt, seafood, and the air we breathe. Microplastics' effects on human health are not yet clear, but studies show that they can build up in the guts of animals and cause internal injuries, as well as boost inflammation. Stemming microplastic pollution starts with reducing production, scientists say. "We have to move away from a throwaway mindset," environmental physicist Laura Revell of the University of Canterbury told C&EN in February 2022.

PFAS

Per- and polyfluoroalkyl substances, or PFAS, have been widely used in industrial and commercial products since the 1940s. These substances, nicknamed forever chemicals, have an impressive ability to repel water, stains, and grease. One early example, Teflon, was serendipitously invented by DuPont in 1938 and marketed after World War II as a nonstick coating for cookware. Today, thousands of PFAS have been synthesized for use in adhesives, construction materials, cleaning products, paints and coatings, cosmetics, textiles, packaging, electronics, explosives, foam fire retardants, and more. In recent decades, however, evidence has emerged from animal and human studies revealing these molecules' harmful effects. PFAS can cause some cancers, disrupt the endocrine system, and interfere with reproduction and fetal development, as well as have other detrimental effects. Companies have phased out several especially harmful PFAS but are replacing some with new, poorly tested alternatives. Governments are working to develop regulations restricting PFAS production, but these degradation-resistant materials have accumulated widely in the environment—and in our bodies. Although technologies are emerging that can destroy these chemicals, so far there's no clear path forward for cleaning up PFAS pollution.

Fossil fuels

Extracting and burning fossil fuels has powered much of the technological progress we associate with modern society and has enabled people to forge connections across the globe. But the products of combustion engines, coal power plants, and petroleum refineries have also caused intense levels of pollution—an outcome too often concentrated in poorer communities. Accumulating studies are revealing the enormous early-death toll of air pollution attributable to fine particulates, nitrogen oxides, and other pollutants produced by combustion. Meanwhile, oil spills and other accidents related to gathering, refining, and transporting these fuels have caused immeasurable environmental damage. On a larger scale, the burning of fossil fuels continues to release carbon dioxide and other greenhouse gases into the atmosphere, driving climate change. The Intergovernmental Panel on Climate Change has declared that to prevent catastrophic consequences, we must drastically reduce carbon emissions by 2030 and reach net-zero levels well before the end of the century, but how the world will address this challenge, both technologically and politically, remains to be seen.

Mining and nuclear waste

Separating valuable elements from ores—for example, extracting lithium to develop batteries or refining gold for jewelry—has become increasingly important over the past century, and these activities' environmental impacts are accumulating. Throughout the 20th century, sequestering mining waste behind dams was widespread. When these tailings dams fail, they can cause devastating floods and environmental damage. A 2019 failure in Brazil, for example, killed 270 people. A 2019 Reuters report classified more than one-third of the world's tailings dams as posing high risks to nearby communities. Nuclear materials carry additional harms. When uranium and plutonium are refined and used in nuclear power plants or in weapons development, they leave radioactive waste behind, "and we have to deal with it," Gerald S. Frankel, a materials scientist at the Ohio State University, told C&EN in March 2020. Accidents, such as the deadly 1986 disaster at Chernobyl and the earthquake and tsunami that severely damaged multiple reactors in 2011 at the Fukushima Daiichi power plant, further raise the stakes of using nuclear power. A considerable amount of radioactive waste remains dangerous over durations that exceed human life spans, and cleanup efforts can require decades and hundreds of billions of dollars….

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Imaging: On the 100 Year Anniversary of Chemical & Engineering News (C&EN) weekly magazine, https://pubs.acs.org/doi/10.1021/cen-10126-cover7

BY: **Mitch Jacoby**, *C&EN*, **2023**, 101 (26), pp 36–37August 14, 2023

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Chemistry’s most powerful tools

Modern chemistry depends on analytical instruments. From the micro end of the spectrum—where researchers study reactions one molecule at a time—to the macro—where engineers run industrial reactors that crank out tons of product—the information that these tools provide enables scientists to track molecules and understand their behavior

Chromatography

Mixing chemicals is relatively easy. Separating them is a challenge, one that long ago led scientists to develop chromatography methods for isolating the components of chemical mixtures. Researchers use these techniques to, for example, identify unknown substances, evaluate the purity of valuable compounds, and assess the selectivity of synthesis methods. Some of the earliest work focused on separating and purifying naturally occurring blends of plant pigments by exploiting differences in the strength with which component molecules bind to particles in a separation column. One hundred years of innovation brought only modest changes to separation fundamentals but extraordinary changes to instrumentation. Around 1950, fully manual methods gave way to powered systems for gas chromatography, a technique for separating volatile compounds. High-performance liquid chromatography caught on in the 1970s, eventually providing ways to separate and analyze a very broad range of compounds, including chiral pharmaceutical agents.

Nuclear magnetic resonance spectroscopy and imaging

Few analytical methods have advanced the practice of chemistry and medicine as much as nuclear magnetic resonance (NMR) spectroscopy and its imaging offshoot, magnetic resonance imaging (MRI). These techniques, which rely on interactions between atomic nuclei and magnetic fields, provide researchers with indispensable tools for determining the structures of molecules in solids, liquids, and gases and for imaging subtle details of tissues and internal organs. Early commercial NMR instruments enabled chemists in the 1950s to analyze relatively small organic molecules, but the size and molecular complexity of compounds analyzed and identified by NMR methods grew rapidly. Researchers today routinely use these instruments to study RNA, DNA, other types of macromolecules, and large inorganic complexes. And they depend on NMR-based methods to continue advancing structural biology, medicine, and materials science.

Mass spectrometry

The mass of an atom, molecule, or microscopic particle is one of its most fundamental properties and has long been used to identify or confirm the presence of these species. Some of the earliest work in detecting atomic masses was conducted in the 1910s by British physicist J. J. Thomson and his assistant Francis William Aston, who built instruments that used electric and magnetic fields to deflect streams of ions. Their work led to the discovery of atomic isotopes. In the decades that followed, researchers made a staggering number of innovations, greatly increasing these instruments' mass resolution and detection sensitivity, broadening their ionization and sample-inlet capabilities, and extending the range of applications in which they are used. Some of today's mass specs are used for single-cell and single-molecule mass measurements, capabilities that can advance biology and medicine.

X-ray crystallography

In the early 20th century, scientists discovered that irradiating a crystal with a beam of X-rays causes the beam to be scattered into many well-defined directions. Father and son physicists William Henry Bragg and William Lawrence Bragg worked out the mathematical theory from which the atomic structure of a crystal could be deduced from the observed scattering patterns. Their work, for which they shared the 1915 Nobel Prize in Physics, remains the cornerstone of modern X-ray crystallography. In recent years, researchers have used the technique to determine the 3D geometry of complex biological structures, such as a P450 enzyme, which plays a central role in cellular drug metabolism.

Microscopy and molecular imaging

For hundreds of years, people curious about nature used magnifying glasses to reveal structures too small to be seen with the naked eye. In the past century, scientists have radically advanced those capabilities, designing instruments that provide unprecedented views of atoms and molecules. Field-ion microscopes and transmission electron microscopes led the way in 1955 and 1970, respectively, generating images in which each dot corresponded to a single atom in a metal specimen. Scanning probe microscopes, which followed in the 1980s, enabled researchers to not only image atoms but also manipulate them one at a time and assemble and study nanostructures. Scientists continue to innovate and devise methods for imaging increasingly complex molecular structures, such as the human preinitiation complex, shown here. This cellular machine transcribes genes and holds the keys to treating many diseases…

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DNA: On the 100 Year Anniversary of Chemical & Engineering News (C&EN) weekly magazine,
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BY: **Laurel Oldach**, *C&EN*, **2023**, 101 (26), pp 38–39August 14, 2023

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Solving the structure of DNA

Deciphering DNA's double-helical configuration launched an era of innovation in medical and life sciences research

In the middle of the 20th century, accumulating data suggested that DNA carries life's genetic information. Biochemists around the world raced to determine its structure. The competition led to some notable misfires, such as Linus Pauling's triple helix. In 1953, James Watson and Francis Crick published a pithy one-page article proposing that two helical ribose-phosphate backbones might form a double helix (*Nature*, DOI: 10.1038/171737a0). They contended that hydrogen bonds might link the bases adenosine to thymine, and guanidine to cytosine between the two helical backbones, adding that the proposed structure "immediately suggests a possible copying mechanism for the genetic material."

In a famous controversy in science history, the discovery relied on X-ray crystallographic data collected by Rosalind Franklin, whose work neither Watson and Crick nor, later, the Nobel committee acknowledged.

The work opened a new chapter in the life sciences. According to David Liu, a chemical biologist at Harvard University, the Broad Institute of MIT and Harvard, and the Howard Hughes Medical Institute, understanding DNA's structure "raised the possibility of reading, synthesizing, duplicating, and ultimately editing the genetic blueprints of all living systems, including people. Each of these possibilities would be realized over the next 70 years, and each was its own transformational breakthrough."

It would be impossible to describe all the advances enabled by understanding the structure of DNA—but here is a small sample.

Sequencing

Once researchers understood how DNA was shaped, they could begin to learn to read it. In 1977, biochemists reported a way to determine the sequence of a template strand. They used labeled bases to stop the replication of the template and determine which base was at each position (*Proc. Natl. Acad. Sci. U.S.A.*, DOI: 10.1073/pnas.74.12.5463). That first method, known as Sanger sequencing, was used for decades for projects as varied as characterizing single genes and assembling the first maps of the human genome.

Its successor, next-generation sequencing, hit the market in 2005. It has made DNA analysis faster and cheaper, enabling researchers to diagnose diseases rapidly, probe the differences in gene expression between individual cells, track pathogen evolution in real time, and catalog the diversity of microbial life. An ongoing challenge has been to enable more equitable access to the benefits of genomics. To yield benefits for all, research studies must include participants and scientists who represent not just populations with European ancestry but "the whole incredible tapestry of human genetic variation," says Keolu Fox, a geneticist at the University of California San Diego.

Oligonucleotide synthesis

In 1966, chemists reported a method to build an oligonucleotide with a desired sequence by anchoring the first base to a bead, then using protecting groups to add subsequent bases one at a time (*J. Am. Chem. Soc.*, DOI: 10.1021/ja00974a053). The resulting short, defined oligonucleotides can be used as primers to start the polymerase chain reaction, which duplicates longer template sequences and became a key tool for molecular laboratories. Over time, researchers found efficient ways to produce long synthetic sequences by stitching together shorter ones; today it is possible to generate a whole synthetic genome this way (*Nature* 2023, DOI: 10.1038/s41586-023-06268-1). As drugs, synthetic oligonucleotides can suppress the expression of disease genes or introduce desirable proteins, such as in vaccines. Some engineers hope to use synthetic DNA to encode and store data as a greener alternative to servers.

Protein engineering

Once researchers understood how DNA encodes proteins, they could use it to change those proteins to suit their needs. Site-directed mutagenesis, a cloning method first reported in 1982, enabled researchers to pluck a single amino acid out of a protein and replace it (*Nature*, DOI: 10.1038/299756a0). Researchers used the technique to study proteins' structures or tweak their activities. Today, engineered proteins are used as catalysts in industry, drugs in the clinic, and tools in the laboratory. Meanwhile, looking to a greener future, researchers use directed evolution to nudge proteins toward novel functions and artificial intelligence tools to design new proteins from scratch.

Genome editing

Since researchers first harnessed bacterial immune proteins to manipulate sequences in living cells, CRISPR has spread rapidly into the public consciousness (*Science* 2012, DOI: 10.1126/science.1225829). Inspired by the protein Cas9, biologists have found and designed additional enzymes that can be guided to a target gene by complementary RNA. While delivery challenges remain for some medical applications, CRISPR-based genome editing has received US Food and Drug Administration approval to treat sickle cell disease (*N. Engl. J. Med.* 2021, DOI: 10.1056/NEJMoa2031054), is in tests for other genetic disorders, and has seen wide use in agriculture. The 2018 birth of twin girls whose genomes had been edited as embryos highlighted the urgency of ethical discussions about genome editing.

Epigenetic intervention

Early in the 20th century, developmental biologists proposed multiple theories to explain how cells containing the same genes can commit to dramatically different fates. The discovery of DNA's structure provided the foundation for exploring how changes unrelated to DNA sequence—either at specific points on DNA or across broad swaths of the genome—can modify gene expression. Today, researchers are becoming savvier about overlaying epigenetic and sequence data from single cells to decipher the biological basis of variation that's not encoded in DNA. In the clinic, researchers are beginning to understand how to use epigenetic changes to predict disease progression or therapy response. Meanwhile, several cancer drugs target epigenetic enzymes.

DNA nanotechnology

For nanoengineers, the double helix is just a starting point for creating more complex structures. With DNA as a building material, researchers can assemble tubes, lattices, and polyhedrons from short DNA tiles or fold longer strands into intricate 3D conformations. Researchers have built whimsical DNA structures, such as a Möbius strip or a tiny lockbox. They are also exploring practical applications, such as fabricating nanowires, etching microscopic nanoelectronics, and building tiny robots. Others hope to build DNA capsules for drug delivery and other therapeutic purposes, moving the field from engineering back toward the life sciences. "We steal material from biology, and we return the favor back to biology," says Hao Yan, director of the Center for Molecular Design and Biomimetics at Arizona State University..

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Energy: On the 100 Year Anniversary of Chemical & Engineering News (C&EN) weekly magazine, https://pubs.acs.org/doi/10.1021/cen-10126-cover9

BY **Alla Katsnelson,** special to C&EN, *C&EN*, **2023**, 101 (26), pp 40–41August 14, 2023 *C&EN*, **2023**, 101 (26) pp 20–21 August 14

Innovation in lithium-ion batteries

As the world's electricity storage needs climb, battery chemistry is advancing apace

During the oil crisis of the 1970s, a chemist at Exxon named M. Stanley Whittingham, working on a new type of rechargeable battery, discovered that lithium ions could slip inside the gaps in a layered material called titanium disulfide. He created the world's first lithium-ion battery, which sported a titanium disulfide cathode and a lithium anode. The device was lightweight and had excellent energy storage capacity, but it frequently short-circuited. John B. Goodenough, then at the University of Oxford, and Akira Yoshino at Asahi Kasei refined the design by switching out the titanium disulfide for cobalt oxide and the lithium metal for petroleum coke. The trio won the 2019 Nobel Prize in Chemistry for the work.

Just 50 years after Whittingham's original invention, lithium-ion batteries have come to power an enormous swath of our world. Our cell phones, laptops, power tools, and electric vehicles all rely on this technology, and demand is now expanding to larger-scale energy storage for electricity generated by solar cells and wind turbines.

Researchers continue to improve on Li-ion batteries' four key components: the cathode, anode, electrolytes through which lithium ions travel, and separators that keep positive and negative electrodes apart. But the need for higher capacity and safer and cheaper power sources is growing, as is the recognition of environmental harms caused by mining metals required for Li-ion batteries.

Spurred by this reality, researchers are exploring a wide array of chemistries and materials for batteries beyond lithium ion. One approach gathering momentum is sodium-ion batteries, which originally gained interest in the 1980s, before lithium ion became the dominant technology.

"There's a whole new chemistry and electrochemistry that has to be developed for sodium," says Linda Nazar, a chemist at the University of Waterloo. For now, this technology's relatively low energy density makes stationary energy storage the most obvious application, but that could change as new research brings improvements, she says. Researchers are investigating other ions, such as magnesium and sulfur, as well as changes in cathode, anode, and electrolyte materials, but most of these approaches have a way to go before commercialization.

Whichever battery chemistries and materials end up on top, the industry will have to address the issue of battery recycling, which today is barely done. "As people get beyond the growing pains of things like electrifying cars, we face hard questions about where those spent batteries go," says Lynden A. Archer, a chemical engineer at Cornell University. The next wave of power storage technology "could be the next big thing for society," he says—but for it to be successful, governments, scientists, and policymakers will have to create frameworks for greening the industry…

Alla Katsnelson is a freelance science writer and editor in Southampton, Massachusetts.

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Green Chemistry: On the 100 Year Anniversary of Chemical & Engineering News (C&EN) weekly magazine, https://pubs.acs.org/doi/10.1021/cen-10126-cover10

BY: **Leigh Krietsch Boerner**, *C&EN*, **2023**, 101 (26), pp 42–44August 14, 2023

The birth of green chemistry

Spurred by legislation, chemists devised a set of principles to rein in environmental harm.

The rise of the environmental movement in the 1960s and 1970s brought a growing public awareness of environmental damage caused by chemical pesticides such as DDT, as well as mounting outrage at chemical companies' dumping practices. These sentiments spurred the notion that the industry could predict the damage its processes and products might have and should aim to limit these impacts prospectively instead of responding reactively to disasters. Green chemistry emerged as a way of achieving these goals after the US Congress passed the Federal Pollution Prevention Act of 1990, which instructed the industry to take a pollution prevention approach.

Green chemistry isn't a particular set of reactions but a framework for thinking about how to design, run, and work up reactions. In 1998, chemists Paul Anastas and John Warner published *Green Chemistry: Theory and Practice*, a book that has become synonymous with the green chemistry movement. In it, Warner and Anastas laid out the 12 principles of green chemistry, a list of doctrines for chemists to follow to make their reactions less hazardous to the environment and human health.

Here are some of the most actively researched principles of green chemistry. But ultimately, the hope is to make the term *green chemistry* obsolete, Anastas says. “We will know when we’ve succeeded when all chemistry is green chemistry.”

Prevent waste
“It is better to prevent waste than to treat or clean up waste after it has been created.”

Economize atoms
“Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product.”

Make it benign
“Chemical products should be designed to affect their desired function while minimizing their toxicity.”

Ditch harmful solvents
“The use of auxiliary substances (e.g., solvents, separation agents, etc.) should be made unnecessary wherever possible and innocuous when used.”

Power with catalysts
“Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.”

Design to degrade
“Chemical products should be designed so that at the end of their function they break down into innocuous degradation products and do not persist in the environment.”

ARTICLE, SEE August 14, 2023 ISSUE

Computational Chemistry: On the 100 Year Anniversary of Chemical & Engineering News (C&EN) weekly magazine, https://pubs.acs.org/doi/10.1021/cen-10126-cover11
BY: **Ariana Remmel**, *C&EN*, **2023**, 101 (26), pp 46–48August 14, 2023

Chemistry goes in silico

Computers have expanded chemists’ capabilities and opened new doors for chemical discovery

Chemistry today is virtually inseparable from computers and the digital landscape they create. The smartphones that scientists carry in their pockets have more computing power than engineers could generate with an entire room full of machines back in the 1950s, when the first general-purpose computers became available. Chemists have applied innovation in computer science to transforming our understanding of the molecular world.

Computational methods allow researchers to investigate the structure, reactivities, and energetics of chemical systems. As machines gained prowess in arithmetic, computational chemists developed new ways to simulate molecular materials in silico. Researchers can now manipulate virtual models of molecules in 3D space on computer screens. With molecular dynamics, these static images come to life in short movies that recapitulate massive chemical systems, such as biological processes in cells.

Humans are producing so much digital information that the International System of Units has gained new prefixes to help accurately describe colossal quantities of data. Vastly improved data storage technologies allow chemists to collate their contributions to this content cornucopia by creating massive libraries of chemical information. With these datasets, researchers can train artificial intelligence and machine learning applications to interpret chemical information with something akin to a human chemist’s intuition. This means that computers can help chemists create elusive and unexpected materials through an iterative process of prediction and production.

It’s difficult to overstate the advances in computational chemistry over the past century, especially since many of the resulting tools now have applications in solving chemical conundrums far beyond their intended purpose. Here, we present some of the ways that chemists harness the power of machines to explore molecular worlds.

Quantum chemistry
Chemists began applying the principles of quantum mechanics to the study of molecular systems nearly a century ago.

Drug discovery
Pharmaceutical scientists searching for medicinal chemicals have massive datasets of biological measurements and chemical libraries of potential drug candidates. .

Chemical simulations
Computers have revolutionized how scientists create models of chemical systems.

Protein design
Almost 70 years ago, the chemical structures of proteins were still a mystery.

Materials discovery
Chemists today have an arsenal of synthetic methods and computational tools at their disposal to develop new, bespoke materials.

Lab automation
The modern chemistry laboratory is packed with computer chips, such as in programmable laboratory equipment and data processing software, that help scientists streamline their experimental workflows

Chemistry communication
The internet has fundamentally changed the way chemists communicate with one another and keep abreast of research…

ARTICLE, SEE July 24, 2023 ISSUE

Global Top 50; Chemical & Engineering News (C&EN) weekly magazine,
https://cen.acs.org/business/finance/CENs-Global-Top-50-2023/101/i24

BY: ***Alexander H. Tullo*** July 24, 2023 | A version of this story appeared in Volume 101, Issue 24

C&EN's Global Top 50 chemical firms for 2023

Despite challenges, chemical makers posted a strong performance

The global chemical industry confronted exceptional challenges in 2022, but overall it ended the year in decent shape.

According to C&EN's Global Top 50 survey, the world's 50 largest chemical companies combined for chemical sales of $1.2 trillion in 2022, the fiscal year on which the survey is based. That is a 17% increase over the results from the same companies in 2021.

The lofty results do come with disclaimers. For the most part, firms attributed the increase in sales to higher selling prices, not increased production volumes. And in 2021, the Global Top 50 posted a 38% increase in sales as the world economy rebounded from the depths of the COVID-19 pandemic.

The picture appears less rosy when chemical profits are measured. The 42 companies in the Global Top 50 that report such data combined for $117.7 billion in chemical profits, a decline of 7% from those firms' profits in 2021.

But this is a modest decrease considering 2022's many headwinds. One was Russia's invasion of Ukraine. It drove up energy prices during the first half of the year and disrupted supplies of natural gas to Europe. Germany, with its dependence on Russian gas, was hit particularly hard. Firms such as BASF had to shut down chemical capacity.
Around the world, central banks raised interest rates to combat inflation, slowing economic growth. And China, long the engine driving chemical industry output, had a difficult year as stringent lockdowns to combat the COVID-19 pandemic crimped economic activity.

Certain sectors of the industry performed very well. Fertilizer makers such as Yara, Nutrien, and Mosaic saw big increases in sales from higher prices. Three firms—CF Industries, ICL Group, and OCI—made the Global Top 50 for the first time because of the strong fertilizer market.

Similarly, the lithium-chemical business has been booming because of demand for electric vehicle batteries. This demand thrust the Chilean inorganic firm SQM into the ranking for the first time.

Alpek made the Global Top 50 on the strength of its core polyester business. The Mexican chemical maker saw sales rise by 36%. Indorama Ventures, another polyester specialist, also experienced a strong rise in sales, at 41%.

A newcomer is Japan's Resonac Holdings, which formed from the merger between Showa Denko and Showa Denko Materials, formerly Hitachi Chemical. The US petrochemical maker Westlake also returns to the Global Top 50 after narrowly missing out last year.

Many firms dropped from the ranking after appearing in it last year. Lanxess and DSM, two European chemical makers, didn't make the cut. Both firms divested large polymer businesses recently.

The Chinese chemical makers Hengyi Petrochemical and Tongkun Group were also edged out by other companies. The fast-growing firms will likely be back on the survey in the future.

Hanwha Solutions and Johnson Matthey both dropped from the list. In tabulating Hanwha's results, C&EN excluded nonchemical photovoltaic sales, which we had counted in previous years. Johnson Matthey saw a sharp drop in sales in its automotive catalyst business during the fiscal year.

EuroChem Group, a fertilizer maker that has Russian ownership and a largely Russian business, didn't publicly report results for 2022.

 # 1: BASF 2022 Chemical Sales: $92.0 Billion. BASF managers would probably prefer to forget about 2022. The overall results for the world's largest chemical company look good: revenues increased 11% while chemical operating profits declined a mere 2%. But the company's home base of Germany was hurt deeply by the European energy crisis. Russia's invasion of Ukraine severely reduced European imports of Russian natural gas. BASF's 2022 European energy bill increased by $2.9 billion over the year before.

 # 2: Sinopec 2022 Chemical Sales: $66.9 Billion. Sinopec is hitching up with another company high in C&EN's ranking, Ineos. The two firms are forming joint ventures that they estimate will generate $10 billion in annual revenues. Ineos bought into Sinopec's existing ethylene cracker complex and is buying a stake in a cracker in Tianjin, China, that is under construction and set for completion later this year. The companies also plan on running high-density polyethylene and acrylonitrile-butadiene-styrene polymer plants together. Like many large chemical makers, Sinopec is making a push into green hydrogen. It is building a plant in Inner Mongolia that will make 30,000 metric tons (t) of hydrogen annually via water electrolysis with renewable energy. An affiliate will use the hydrogen to make chemicals, such as olefins and methanol, from coal. Sinopec says that compared with using coal to generate the needed hydrogen, the process will cut nearly 1.5 million t per year of carbon dioxide emissions.

 # 3 Dow, 2022 Chemical Sales: $56.9 Billion. Dow plans to become the first major company to build a nuclear power plant at a chemical complex to reduce greenhouse gas emissions. In May, the company selected Seadrift, Texas, as the site for installing a modular nuclear reactor designed by X-Energy Reactor. Set to come on line by the end of the decade, the reactor will supply heat and steam to the petrochemical complex, cutting 440,000 metric tons of carbon dioxide emissions per year. Nuclear power has advantages over other low-carbon energy sources, such as wind and solar, in that it produces electricity more steadily because it doesn't depend on the weather. Dow has diversified wagers on low-carbon energy. In Alberta, the company is converting the heat source for its ethylene cracker to hydrogen and will use carbon capture and storage to mitigate CO_2 emissions from the hydrogen production. It also plans to buy ethylene made from cellulosic ethanol that the start-up New Energy Blue will produce from corn stover in Iowa.

 # 4 SABIC, 2022 Chemical Sales: $48.8 Billion. Since its inception in 1976 as a state-owned chemical maker charged with upgrading Saudi Arabia's hydrocarbon resources into chemicals, Sabic has always had big-ticket construction projects in the works. Last year, the company started up a $10 billion petrochemical project in Texas with ExxonMobil. Now Sabic is studying the construction of a large oil-to-chemical complex in Ras al-Khair, Saudi Arabia. In addition, Sabic and SK Geo Centric are expanding a joint venture in Ulsan, South Korea, that uses SK's Nexlene technology to make low-density polyethylene, elastomers, and plastomers. Sabic is also considering installing a Nexlene plant at Motiva Enterprises' refinery in Port Arthur, Texas. Like Sabic, Motiva is controlled by the oil company Saudi Aramco.

 # 5 ExxonMobile, 2022 Chemical Sales: $47.5 Billion. ExxonMobil is serious about making a business out of carbon sequestration. It is moving forward with a project in Baytown, Texas, to capture and store 7 million metric tons (t) per year of carbon dioxide generated during hydrogen production. ExxonMobil will use this low-carbon, blue hydrogen for its chemical operations and to make ammonia. South Korea's SK has already agreed to buy ammonia from the complex. In January, ExxonMobil awarded the engineering contract to Technip Energies. The oil and gas company is also eager to provide CO_2 transport and storage to third parties. Over the past year it has signed contracts with the fertilizer maker CF Industries, the industrial gas supplier Linde, and the steelmaker Nucor covering 5 million t of CO_2 per year. ExxonMobil is also planning a hub in the UK that would capture and store 3 million t per year of the greenhouse gas.

 # 6 Ineos, 2022 Chemical Sales: $41.2 Billion. Long a major European and US player in petrochemicals and plastics, Ineos is now making a push into Asia. Last year, it signed a series of deals with Chinese oil and chemical producer Sinopec that could together generate about $10 billion in annual sales. Ineos purchased a 50% interest in Shanghai Secco Petrochemical, which had once been a joint venture with BP. Ineos and Sinopec also agreed to join on future projects in acrylonitrile-butadiene-styrene polymer and high-density polyethylene. Ineos bought Mitsui Chemicals' phenol complex on Jurong Island, Singapore, for $330 million in April. In Europe, Ineos is buying out TotalEnergies' interest in an ethylene cracker joint venture in Lavéra, France. Ineos may soon be diversifying in dramatic fashion. The firm is reportedly in the running to buy Manchester United. Ineos founder Jim Ratcliffe has always been a supporter of the soccer club.

 # 7 Formosa Plastics, 2022 Chemical Sales: $40.2 Billion. Some chemical projects remain in a holding pattern forever. They aren't canceled formally; they are just quietly shelved. One of these might be Formosa Plastics' $9.4 billion petrochemical project in Louisiana, originally announced in 2015. The plan has always faced stiff opposition from the local community and activists, who have scored major victories. In 2021, the US Army Corps of Engineers ordered a full environmental review, and last year a local judge pulled the air permits. Formosa's project website hasn't been updated since 2021, and the firm still hasn't reached a final investment decision. The company is, however, pressing on with a more modest project in its home country: an expansion of its styrenic block copolymer joint venture with Kraton in Mailiao, Taiwan.

 # 8 LG Chem, 2022 Chemical Sales: $40.2 Billion. LG Chem is stepping up investment in battery materials. In November, the South Korean firm revealed plans to build the largest cathode material facility in the US. The $3 billion plant, in Clarksville, Tennessee, will have the capacity for 120,000 metric tons per year of nickel, cobalt, manganese, and aluminum cathode materials. A few months earlier it signed an agreement to supply cathode materials to General Motors. This April, LG Chem and Huayou Cobalt announced a joint venture to build a $900 million plant for cathode precursors near Seoul, South Korea. In South Korea, the company started construction on a plant for carbon nanotubes, which are used in cathodes. LG Chem is also active in biobased chemicals. With ADM, it's building lactic acid and polylactic acid plants in Decatur, Illinois, that will start up in 2026. And with the industrial biotechnology firm Gevo it is working on a biobased route to the chemical building block propylene.

 # 9 LyondellBasell Industries, 2022 Chemical Sales: $39.5 Billion. LyondellBasell Industries has ambitious plans in circularity. In Wesseling, Germany, near Cologne, the company is building the first plant to use its MoReTec technology, a catalytic process that breaks down waste plastics into petrochemical feedstocks. LyondellBasell's vision is for Wesseling to become an integrated center for recycling all kinds of plastic waste. Some would be mechanically recycled. Plastics that don't lend themselves to mechanical recycling, such as flexible packaging, would go through chemical processes like MoReTec. LyondellBasell aims to establish a similar system in the US as part of a plan to repurpose its Houston refinery, which the company has slated to close in early 2025. The firm is also considering low-carbon hydrogen projects at the location.

 # 10 PetroChina, 2022 Chemical Sales: $38.3 Billion. The Chinese economy struggled in 2022 as the government imposed severe lockdowns and other restrictions to fight the COVID-19 pandemic. PetroChina's results show it. The company's chemical business posted a loss for the year, and revenues rose by only 8%. The sales increase was primarily due to rising prices, not improving volumes. The company is still making progress on big projects. It recently completed a 600,000-metric-ton-per-year acrylonitrile-butadiene-styrene polymer plant in Jieyang, China. And the company is working on expansions at its PetroChina Guangxi Petrochemical and PetroChina Jilin Petrochemical subsidiaries. The total budget for these projects is $9.5 billion.

 # 11 Hengli Petrochemical, 2022 Chemical Sales: $31.1 Billion. As a large Chinese petrochemical maker, Hengli Petrochemical was hit with weak domestic demand in 2022 because of pandemic lockdowns and rising prices for oil. "Confronted with formidable challenges, we have cut through thickets and advanced toward the light, steadfastly growing amidst tremendous changes and uncertainty, resolute in our forward pursuit," chair Fan Hongwei writes in a letter to shareholders in the company's annual report earlier this year.. Hengli is indeed pursuing a lot this year. The company is starting up plants for acrylonitrile-butadiene-styrene polymer, polycarbonate, adipic acid, and butanediol. It is also installing capacity for lithium-ion battery separators.

 # 12 Air Liquide, 2022 Chemical Sales: $31.0 Billion. In recent years, the French industrial gas specialist Air Liquide has heaped a lot of investment onto electronics and low-carbon technologies. It is spending $70 million in North Texas to expand plants that make high-purity oxygen and nitrogen for semiconductor producers and to build a new plant. At the same time, the company is negotiating the sale of its aerospace O_2 and N_2 business to Safran Aerosystems. In low-carbon technologies, the firm's Cryocap technology will be installed at a carbon capture project at a Holcim cement factory in Belgium. The plant will capture CO_2 using cryogenic temperatures instead of the more typical amine solvents.

 # 13 Linde, 2022 Chemical Sales: $30.6 Billion. The industrial gas maker Linde is positioning itself as a third-party supplier of low-carbon hydrogen. For example, it will build an autothermal reformer at its site in Alberta that will generate hydrogen from natural gas. Dow will use the hydrogen as a fuel for its nearby ethylene cracker. The carbon dioxide generated in the process will be captured and stored. Additionally, Linde plans to spend $1.8 billion to build an autothermal reformer that will supply hydrogen to an ammonia plant that OCI is planning for Beaumont, Texas. As part of that project, Linde has chosen ExxonMobil to transport and store the CO_2. In a similar venture, Linde plans to install an electrolyzer in Niagara Falls, New York, to make hydrogen from water using hydroelectric power.

 # 14 Mitsubishi Chemical Group, 2022 Chemical Sales: $29.4 Billion. Mitsubishi Chemical Group CEO Jean-Marc Gilson is worried about the future of the Japanese petrochemical industry. The sector has been suffering under high energy prices, a weak Japanese yen, and stiff competition from energy-rich regions like the Middle East. “It’s forcing consolidation in Japan, because four or five players can’t survive there,” he told a petrochemical conference in Houston in March. Mitsubishi plans to carve out its petrochemical and coal-based operations as a separate company. Mitsubishi will instead focus on specialty chemicals, which have a stronger future in Japan. To this end, Mitsubishi has opened a research facility in Yokohama, Japan. The company is setting priorities abroad as well. It is considering closing its methyl methacrylate (MMA) plant in Billingham, England, that has made the acrylic monomer since 1930. It has also delayed a final investment decision on a new MMA plant in Louisiana.

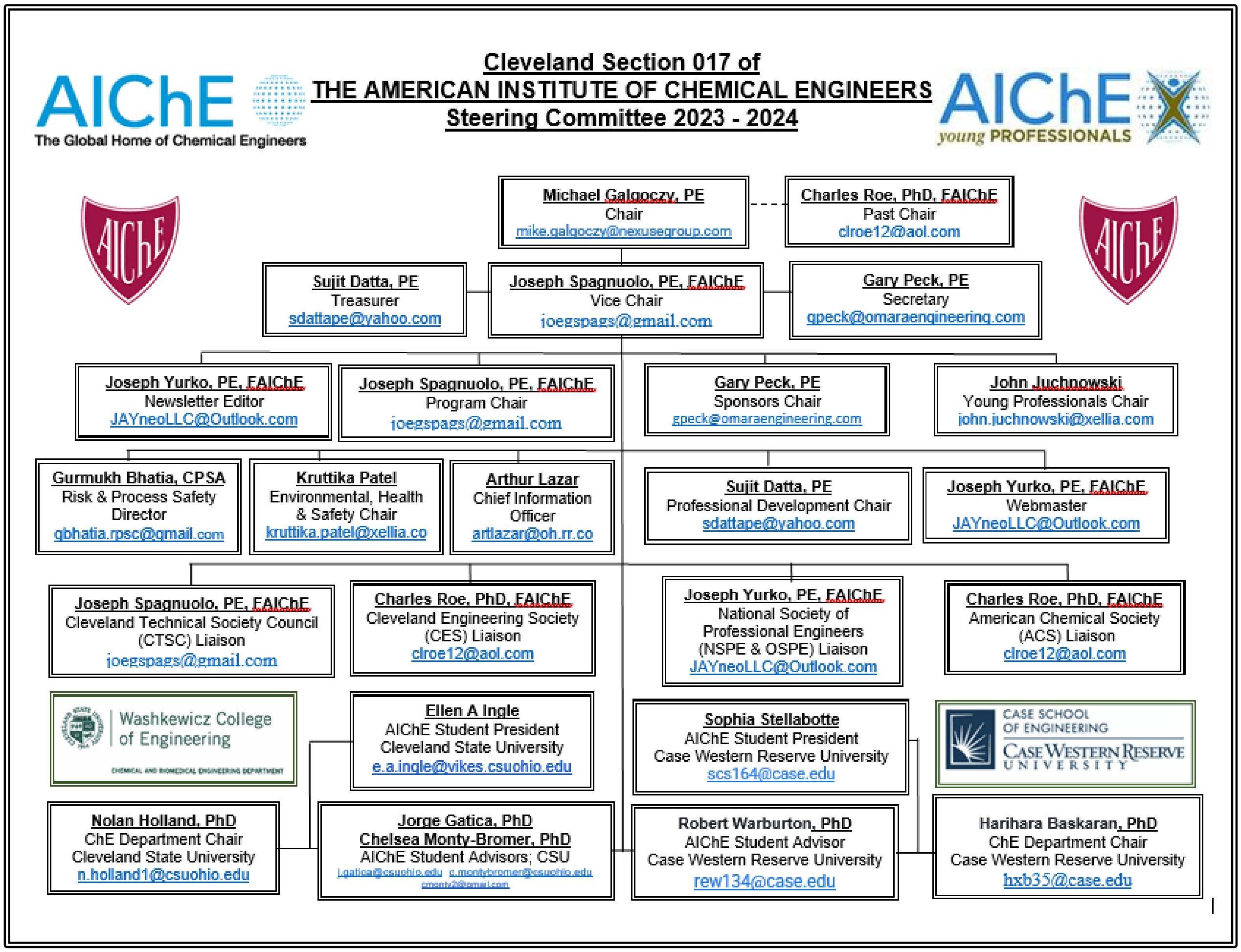
 # 15 Syngenta Group, 2022 Chemical Sales: $28.5 Billion. In May, Syngenta Group, the crop protection arm of the Chinese conglomerate Sinochem Holdings, introduced what it is calling a breakthrough herbicide—tetflupyrolimet—for the control of grass weeds that affect rice in Asia. Developed by FMC with Syngenta’s support, tetflupyrolimet is the first major herbicide with a novel mode of action in 3 decades, according to the companies. Syngenta is also investing in biological crop protection technologies. It is working with Biotalys on biological insecticides. And in September, Syngenta was named the exclusive distributor of a microbial seed treatment, made by Bioceres Crop Solutions, that improves nitrogen uptake for soybeans…

CLE AIChE: Cleveland Chapter

Fall 2023 – Spring 2024 Program Planning

(as of Nov2023)

Month	Topic, Speaker	Location	AIChE Officer Responsible
September 8, 2023 (Friday 6 PM)	Oktoberfest Social Event	German Central Farm, Parma	Joe Yurko, $7/guest admission + $ food & beverage at buffet line? Attending: 3 Pros, 5 YPs, 1 CSU Student
October 11, 2023 (Wednesday 6 PM)	Brewery Tasting Tour	Market Garden Brewery, Ohio City	Mike Galgoczy, $20/guest with 20 guests. 20 Attending Dinner: 7 PM Market Garden Brewpub & Restaurant.
October 30, 2023 (Wednesday 5:30PM)	ASM Joint Meeting: Heat Treater's Night H2 effect on heating metals, Justin Dzik, PE	FIVES North American Combustion, Inc., Talk & Tour	Joe Spagnuolo & Joe Yurko: $30 Non-members, $15 Retirees, $5 Students. Attending: 2 Pros, 3 CSU Stu https://www.fivesgroup.com/energy-combustion
November 14, 2023 (Tuesday 6 PM)	History of ACS 7-National Chemical Landmarks Sites in Cleveland, Helen Mayer Speaking	The Sanctuary, Rockside Road Independence	Joe Yurko, Dinner menu ordering for professional members, Students cost: $5 Attending: 16 Pros, 2 YPs, 1 CSU http://places.singleplatform.com/shulas-steak-house-8/menu#menu_5599999
December 7, 2023 (Thursday 6 PM)	Nuclear Power and Decarbonization Update for Ohio, Andrew & Kris Ohrablo Speaking	The Sanctuary, Rockside Road Independence	Joe Yurko, Dinner menu ordering for professional members, Students cost: $5 http://places.singleplatform.com/shulas-steak-house-8/menu#menu_5599999
January 2024	NASA Glenn Center Vertical Take Off & Landing (eVTOL) Electric Aircraft, JOBY, Dayton, OH	Cuyahoga County Public Library (CCPL) Strongsville	Joe Yurko, Dinner menu ordering for professional members, Students cost: $5; Professionals cost: $10 (Cash, Homemade Meal)
February	Process Hazard Analysis, Gurmukh Bhatia Speaking	Cuyahoga County Public Library (CCPL) Independence	Joe Yurko, Students cost: $5; Professionals cost: $10 (Cash, Homemade Meal)
March	Engineering in Oil Refining, Petroleum Midstream, Chemicals, Energy, and Renewables; Marianne Corrao Speaking	Cuyahoga County Public Library (CCPL) Independence	Mike Galgoczy NEXUS: 216-404-7867 Students cost: $5; Professionals cost: $10 (Cash, Homemade Meal)
April	NEOSEF Awards Banquet	CSU Washkewicz Hall, Rm 349	Joe Spagnuolo, Moderator NEOSEF Students, Prof. Nolan Holland, CSU ChE Lab Tours, $15 members, Students Free



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