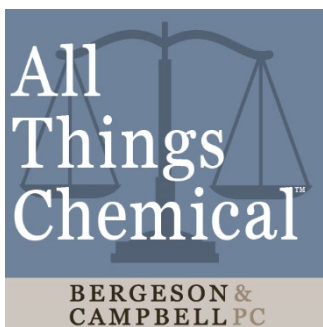




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Lynn L. Bergeson (LLB): Hello and welcome to *All Things Chemical*, a podcast produced by Bergeson & Campbell (B&C®), a Washington, D.C., law firm focusing on chemical law, business, and litigation matters. I am Lynn Bergeson.

This week, I had the pleasure of speaking with Dr. Adelina Voutchkova, Director of Sustainable Development at the American Chemical Society (ACS), and my colleague, Dr. Richard Engler, B&C's Director of Chemistry, to discuss the ACS's much-coveted Green Chemistry Challenge Awards and ACS's Green Chemistry Institute (GCI). Institutionally, GCI has grown as the imperative for greener and more sustainable chemicals has increased. So also have the stature and opportunities to compete for the Green Chemistry Challenge Awards. We discuss the institute's mission and some new opportunities for competing for the Green Chemistry Challenge Awards. Now, here's my conversations with Drs. Voutchkova and Engler.

Adelina, I had the pleasure of visiting with you a bit before recording this podcast, and we here at B&C have long admired your work as Director of Sustainable Development at ACS, and of course your leadership at the ACS Green Chemistry Institute. Let's start off by welcoming both you and Dr. Engler to the studio again to talk about the Green Chemistry Challenge Awards and other issues pertinent. Thanks so much for both of you being here.

Richard E. Engler (REE): Always a pleasure.

Adelina Voutchkova (AV): Thank you so much, Lynn. We're looking forward to it.

LLB: We know a lot about you, Rich, because you've been a frequent visitor here to the studio. But let's start off, Adelina, with learning a bit more about you personally. Give us some of your background, how you found your way to the leadership position you now have at ACS, and other aspects of your illustrious career.

AV: I'm not sure about illustrious, Lynn, but I'm happy to give you a glimpse into what drove me to pursue this particular opportunity at ACS. Again, thank you for the kind introduction. Going back a couple of chapters in my life, my path to ACS GCI really began long before my professional career. I grew up in Jamaica, which is, as I'm sure you know, an island. Sustainability is really at the forefront when you grow up with a finite amount of resources and also a finite place where some of the products that are imported into the island can end up. It was always, to me, quite apparent that we didn't have much of a consideration of end of life. All you had to do was look at our local river and see the pollution and trash that it was accumulating from all the imported products, and then go down the road a little bit to the bauxite manufacturing plant, where we had some of our natural resources being exported out, and no real consideration to what the economic impact would be once those resources were depleted.

That really shaped my challenge going forward as to how we might be able to apply sustainability in a closed system, like the island of Jamaica. I was always passionate about chemistry, and so it was always a question of how do I use chemistry to do something that could be potentially beneficial to that type of closed-system community. Of course, over the course of that education and career, I looked to stay with my conviction that sustainability has to start with chemistry.

In my graduate work at Yale, I had a pivotal moment. A lab colleague of mine fell ill, and I was working in an organic synthesis lab, where we were in contact with various different kinds of metal compounds, organic compounds, but often with very little consideration for how those compounds interacted with us, because when you're creating new chemistry, you don't know what the hazards of those new compounds are going to be. You rely on very limited information on health and safety that's available. When that happened, it was a profound wake-up call, a reminder that even as a chemist, we often design and handle molecules without fully understanding what they can do as potential hazards to us.

That set me on a path to then pursue postdoc, which was really like another Ph.D., I should say, because it was in a completely different field from the organic synthesis and catalysis I pursued in graduate school with Paul Anastas, who at the time was starting the Center for Green Chemistry and Green Engineering at Yale when I was about to graduate. He asked if I worked on toxicology because I told him a little bit about my passion for health and safety, and so that put me on a path to also understand a little bit about how chemicals interact with our bodies and how we can use the collective knowledge we've gained from the physical-chemical properties of these chemicals, from the way they interact and react in a test tube to be able to design chemicals that are ultimately safe for us.

That's been a real passion of mine, and I carried that mission forward into my faculty career at George Washington [University] (GW). There I tried to build a research lab that tried to bridge those two focus areas, both the design of greener processes with catalysis, and then the design of inherently safer molecules. One of the most rewarding aspects of that work, when I think back, was watching students from one of those fields -- from catalysis, for example -- try to teach students in the toxicology subgroup a little bit about how their chemistry impacts the other side, and learning how some of the computational tools can be applied to both reactivity -- understanding how molecules will interact in a test tube, but also then extrapolating that to how they react when they are in touch with our bodies, when we get a highly reactive compound on our glove, for example.

I think that was impactful to the students, but it was also really impactful to me, that we need both aspects. We need to be able to understand the chemicals themselves and also the

processes. That's ultimately what's driven me to the position that I have today here at ACS. An opportunity arose at an unexpected moment to take this position, and it was really a life-changing moment for me. I was a tenured faculty member at George Washington. I really cherished my students, my colleagues, and the department -- and I still do -- and the decision to leave that tenured position and take on this role at ACS GCI was really pivotal in my career, but I knew that there was a mission of GCI that really aligned with my values and my desire to try to bridge the different parts of the chemistry so that green chemistry could be addressed in a more holistic way. I'm happy to tell you more about the work of GCI later.

LLB: Sure. What a perfect blending of your personal interest and your background. Who knew that growing up on a beautiful tropical island like Jamaica would be so influential and impactful on your selection of choices as a professional? Do you continue to be a research associate, a professor at GW?

AV: I've currently closed my lab, which was an emotionally charged moment for me, but --

LLB: I'll bet.

AV: -- to focus my entire energy on GCI and its mission. I think we have a real opportunity to impact many other researchers, educators, and industry, as well as the companies within them that I think make this decision worthwhile.

REE: One of the things early on that I realized about green chemistry is, too often, a chemist in the lab -- especially a graduate student in the lab, but it's generally true in people who work at the bench -- is the chemist reaches for what's nearby. They pick the reagent, or the solvent, or whatever it is, because it's there on the shelf, and there's not a lot of intent about "Why am I choosing this? Are there other alternatives that can be used?" Adelina's background sort of brings that -- she brings that intentionality to her approach to chemistry, and that's what green chemistry is about, is getting chemists to think, be more thoughtful, and be more intentional about why they're selecting what they're selecting, and is there a better choice?

LLB: Rich, while we're at it, why don't you remind our listeners what *your* background is in green chemistry? Not only are you passionate about it, but professionally you've devoted much of your career to green chemistry in one form or another.

REE: Yes, I joined the U.S. Environmental Protection Agency (EPA) in late 1997, which was shortly after the Green Chemistry Program was launched at EPA. The Green Chemistry Program grew out of the Pollution Prevention Act of 1990 (P2 Act). There were a variety of pollution prevention chemistry efforts that grew out the P2 Act. There was one on alternative synthetic pathways: Can you design a synthesis or a manufacturing method that's more efficient or uses or generates less of a hazardous substance, or uses a less hazardous substance or generates a less hazardous substance? There are also alternative solvents. Can you pick a greener solvent if you have to use a solvent? And the last was designing greener chemicals. Can you design the molecule itself to be less hazardous so that -- the idea of designing -- across all three of those areas, you're trying to design the hazard out of the chemistry that you're doing.

The awards were launched in 1995. The first award year was 1996. Then the Green Chemistry and Engineering Conference was launched in 1997, and I joined at the end of 1997. From there on -- from December 28, I think was my first day at EPA of 1997, to this day, I've been involved in and really excited about the opportunities of green chemistry. It

really is an entirely different way of looking at chemistry. Even now, all these decades later, there's still a lot of work to be done about getting chemists to change the way they approach -- and it's not just companies and students, but really across the entire chemical enterprise. Can we be more thoughtful and more holistic in our approach to making our economy more sustainable? Because green chemistry is the science that underlies sustainability.

LLB: Well stated. In that regard, and Adelina, the ACS Green Chemistry Institute's mission -- and I'm paraphrasing here -- is to catalyze the implementation of innovative approaches to chemistry and engineering that enable development across the globe. In reading that and preparing for this podcast, I recognize how broad that mandate is. Can you help us understand more specifically how GCI achieves its mission?

AV: Absolutely. Before I do, though, I have to mention I have the most fond memory of meeting Rich --

LLB: -- We all do!

AV: -- at one of the first Green Chemistry and Engineering Conferences I attended as a graduate student, and Rich was sitting at the EPA desk, and we were curious graduate students trying to understand how some of these awards were being implemented. I remember him inviting us to attend one of those next award ceremonies that took place in D.C., so, Rich, thank you for bringing the early-career researchers into the space, because you've seen the entire trajectory of the history of these awards. It's really great to see how involved you've been and how passionate about the awards themselves, and recognition mechanisms, and getting companies to nominate these technologies. Thank you for all of that leadership.

But let me turn to your question next. I'm sorry, I couldn't miss that one.

LLB: No, we appreciate that, Adelina. We all admire and really marvel at Rich's continuing passion. Although you've been at it a long time, Rich, your passion for green chemistry has not muted one bit. It's every bit as vibrant and as instrumental in development among our clients and interested others as it was probably 20 years ago.

AV: It's wonderful to be able to continue to collaborate with you and with Rich. In that vein, GCI has a very broad mission, as you very well stated, but it really reaches across research, education, industry, and equity. We look to bridge academia, industry, and global communities to work together toward implementing green chemistry in a meaningful and impactful way.

What that translates to is we have to identify how those sectors can reinforce each other in that pursuit of green chemistry. We do things like fund and showcase innovation, but we also provide practical tools, teaching resources, and real-world incentives. We try to help embed sustainable chemistry into practice through both some of these tools that I mentioned, but also by getting educators to interact more with colleagues in industry, by providing some support to their students, by providing curricular support for educators and helping them connect with each other, most importantly, building those global networks, and helping to grow the next generation of the green chemistry practitioners who will cross all those sectorial boundaries. They may be educators one day, working in industry the next day, and being able to influence policy in a different context. We want them to understand all the facets that are critical to implementing green chemistry.

I'll just hone in a couple of those aspects that I think have been really impactful from my outsider's view coming into this position, and now as more of an insider understanding how some of these programs have evolved over the course of the last couple of decades. Rich mentioned that 1997 is the pivotal, auspicious moment where GCI was launched from the Green Chemistry Challenge Awards and the first Green Chemistry Engineering Conference. It later became adopted under the umbrella of ACS in 2001.

One of the key initiatives that was launched was the Pharmaceutical Roundtable, which was the first industry group that really set out to change the way its own members engaged in green chemistry but then also changed the ecosystem of how its potential partners and stakeholders -- like academic researchers -- would be able to engage with researchers in industry and also help bring some of that knowledge of the innovation gaps into their labs, be able to solve some of these challenges and bring those innovations back to industry.

I've seen this group grow substantially over the course of my career as well, when I was first introduced to it back before starting at GCI. Now it has really extended its membership reach. We have over 50 companies that engage in this group, and we've used this model to also, under other industries, we've had round tables for chemical manufacturing and even oil field chemistry. Right now, the one that is growing substantially is the Natural Polymers Consortium that was launched just a couple of years ago with a few companies that came to us and said, "We're looking for a pre-competitive collaboration to help address some of the key challenges with implementing natural polymers in a more substantial way across the chemical supply chain and being able to develop some of applications that can be most impactful."

That industry engagement, I think, has really been a pivotal part of how GCI's mission translates to the real world. It's not just about the research in the labs -- that's also an important part, but it doesn't end there. We need to see green chemistry being implemented in industry, and we need to see what resources industry further needs to help them propagate that integration. For example, we're launching a professional development course in fundamentals of green chemistry for researchers, both graduate students, but especially targeted toward researchers in industry who want to have at their fingertips tools for selecting solvents that are more benign, for being able to identify a way of heating their reaction that's more efficient, applying the right catalysts, very practical synthesis and manufacturing-based tools that are tied to quantifying how much impact that process has.

That ties to green chemistry metrics, including the process mass intensity-type metrics and small-scale reaction metrics as well. That, I think, is just showcasing the connection between industry and academia in that we need to be able to improve some of the skill sets of everyone in the chemistry ecosystem -- from students to professionals who have long left their respective academic institutions and are now fully able to integrate some of these technologies -- and then of course, integrating research from the labs as well, back into industry. These are some of the aspects of the work of GCI that make me really optimistic and excited as to how we can help continue to engage with industry, listen to what some of the challenges are, and hopefully develop more initiatives that help to address those exact pain points and bottlenecks that they're experiencing.

LLB: I'm sure if any of our listeners had more questions about either the professional development course or toolbox that you mentioned and the Natural Polymers Consortium that that's available on your website?

AV: Absolutely is. And if you sign up for the GCI Nexus Newsletter, this first course will be launched later this year, the end of the year now. We're in December, so we will be sending out information to all of our mailing list.

LLB: Rich, you and I were chatting about this recently, but is there a difference between green chemistry and sustainable chemistry? Perhaps Rich, you might want to take a shot at that first, and then Adelina, if you would comment, I think our listeners would find that very interesting. I've often wondered, is this duplicative, or redundant, or what?

REE: I think it depends on who you ask. I don't see a lot of daylight between them. I think there are some good reasons that people would rather call green chemistry sustainable chemistry. There's political -- especially in Europe, the Green Party is a political party. So is green chemistry associated with the Green Party? There's that aspect of it. There are also some people who think that green chemistry is not academically rigorous; it's not like real chemistry. Are you -- ?

LLB: Really? That surprises me!

REE: Yes, there's just a different mindset about the term, which is a fair criticism. I see that as an educational opportunity rather than saying, "Let's rename it." I don't have a problem with the term "sustainable chemistry." I cut my teeth on green chemistry, so I'm a bit defensive of it. I think the most cogent argument I've heard is that green chemistry does not include an economic aspect of it, that somehow green chemistry is just about the hazard, the design of chemical products and processes that reduce or eliminate the user generation of hazardous substances. It's just about lower hazard. There's none of the practicality of getting it -- can you make it work in the marketplace? And that's an important aspect of sustainability. If it doesn't work economically, then it's not going to be adopted. It's not going to achieve its end.

But I think that's embedded in the definition. If you've designed a less hazardous product or process, but it does not get implemented, then it doesn't meet the part of the definition where it's the design of products and processes that reduce or eliminate. If you're not getting to its implementation, your design is not done. You need to go back and do it again to incorporate those more practical aspects of it, the practicability or the economic viability of it. That's just my perspective. I know that's not shared across the community. I don't battle against one name or the other. I think they're fairly synonymous.

LLB: Adelina, what is your thought?

AV: I agree with everything Rich says, as usual, but I would add to this that I've had to grapple with this, both in the classroom -- as students were very curious as to how we distinguish these impractical terms, and then as we look to see how these terms are adopted in real, practical applications. I think of green chemistry as a scientific and technical toolbox, and sustainable chemistry is the broader system-level goal.

As Rich defined, there's a set of principles, 12 principles that still stand to this day, that help provide very specific ways that green chemistry can be implemented at the lab scale, at the bench. Then sustainable chemistry has to expand beyond that to consider, as Rich said, the social, the economic, environmental dimensions, the full life cycle. Think of green chemistry as the methods, sustainable chemistry as the mission. Green chemistry will always provide us the tools that we need, but we need to think about sustainable chemistry,

system-level outcomes. That means we need to speak to industry, strategy, to global development, to policy, to societal impact.

I think of organizations like the ACS GCI that have to operate at that intersection. We have to advance green chemistry, but how? We have to then enable sustainable chemistry, which is -- what is the broader goal? And then we tie that to the U.N. [United Nations] Sustainable Development Goals as a global aspiration that helps us have a goalpost, if you will, toward which we want to work that is broader than just even sustainability itself. It includes equity, access, and quality of life for all people on the planet.

LLB: That's helpful; that was a useful discussion. One quick follow-on thought: Is there a quantitative dimension to what is sustainable? I mean, do you have to meet a certain metric, or is it just you know it when you see it?

REE: There are many ways to measure, and there are a lot of different aspects of it. This is one of the challenges of measuring the success of green chemistry or sustainable chemistry is the many different aspects that need to be measured, and can you -- or how might you -- weight the different aspects of it? If you've found a way for your process to be much more material efficient, but it's less energy efficient, which one? There may be a trade-off there. There are instances where you have some trade-offs, and there are so many aspects of sustainability, besides just reduction of pollution, energy efficiency, material efficiency, land use, and then the equity issues that Adelina brought up.

The U.N. Sustainable Development Goals give that goal post. That *is* the goal, but you may not be able to maximize all of those in every decision, but thinking about them and making, again, very intentional decisions about how do I meet as many of them as I can in what I'm designing? Whether it's a system design, or a chemical reaction, or a choice that you're making, use those to guide your thinking beyond just, "I've got to get this reaction done by the end of the week or my PI [principal investigator] is going to flunk.

LLB: Right. Any comment, Adelina?

AV: That's quite well put, Rich. I think, ultimately, as we're trying to grapple with this distinction and the broader goals, we've got to go back to what does it take to achieve those, and how do we measure those at the individual level? Going back to process efficiency: for example, how do we measure process efficiency? What are the appropriate metrics that are specific to that scale of process? If you're doing something on the lab scale, it's not the same as doing something on a metric ton scale.

Going back to hazard, how do we quantify hazard? Of course, toxicologists have provided us many different schemes for being able to do this, but then you have to get quite specific about the application of the chemical that you have in mind and think about what are the appropriate methods for alternative assessments that speak to that particular type of application. Again, we've got groups of professionals who have helped us outline these kinds of sub-metrics, if you will, within each of the components of green chemistry. But I think your point is a really important one, that we *do* have to be quantitative. It's not sufficient for the market, for the community, to be hand-wavy, if you will, or qualitative because we're held to a higher standard, and we risk the reputation of our field if we're not specific and provide quantitative metrics that can speak to why product A might be better in some ways, but maybe not in all ways, than product B.

I think that's a message to industry as well, that we should continue to look for ways to be more transparent on our product labels, and that will provide consumers the type of information that they will use to reward labels that are associated with products that really bring additional benefits to the environment and to human health. There are many ways we can think about doing that, but I know the pharmaceutical industry is also interested in that level of transparency as well, because as you can imagine, looking at the box of a pharmaceutical ingredient, you don't see much about how it was produced, let alone how that impact translates to broader system effects to biodiversity and the like.

We have to continue to have that conversation and continue to connect green chemistry and sustainable chemistry as a goal to what's in sustainability reports for companies that are putting those out and then what's on product labels for companies that are producing products, and how we communicate that in a way that is not seen as greenwashing. I am very passionate about quantifying those aspects, as you can hear. But I think it's for a reason that we need to make sure trust in science, which is a major strategic goal of ACS, continues to thrive and not perish in this very charged political environment.

LLB: Let's pivot to the Challenge Awards. A key initiative of the American Chemical Society is its long sponsorship of the annual Green Chemistry Challenge Awards. You both are very passionate about green chemistry, obviously, and both have a long professional devotion to supporting green chemistry and defining it, expanding upon it, and ensuring that others see the societal benefit of green chemistry. Rich, please remind our listeners how you connect to the Challenge Awards over your career, particularly at EPA. Then we'll move over to Adelina to tell us about the coveted awards from your perspective.

REE: When I first started, green chemistry was a major part of my assignment workload. It was, again, relatively new, so there was a lot of growth opportunity there, and EPA needed staff support. I worked with Paul Anastas and Tracy Williamson. Early on, Mary Kirchhoff, who was GCI Director at ACS for a while, Lauren Heine. And then other staff at EPA, Joe Breen. And Daniel Lin and other folks there that supported the program, Carol Farris. As a team, we worked together to support the grants program. EPA was giving grants to GCI, as well as other institutions at ACS, to develop educational materials or to support the mission of broadening awareness of and implementation of green chemistry.

But a key part of that was the awards, the Green Chemistry Challenge Awards, then the Presidential Green Chemistry Challenge Awards, were an opportunity to shine a bright light on great technological success in making giant strides toward sustainability. Across the focus areas, the greener synthesis, the greener solvents, and the design of greener chemicals. And then specific awards for academic and small businesses. It was really holding up these examples of what *can* be done through green chemistry. It helped shine a light on the technological, the scientific rigor, but also the benefits.

It was real, and it formed a suite of technologies that could then be used to build -- when you're talking about educational materials, here are some examples educational materials can point to. My entire time at EPA, I worked on green chemistry, and I led the program for about a dozen of my years there. It was one of the reasons that I came here to B&C and The Acta Group (Acta®) was to help grow the green chemistry practice, but TSCA has sort of taken on a life of its own, and I have not had quite the bandwidth that I had hoped for to champion green chemistry in a broader way.

LLB: You *are* championing green chemistry. You're always nurturing innovators who are promoting green chemistry, both in the laboratory practices and in product development. You've been hugely influential in that regard.

REE: But the awards still are serving that purpose of these are the great examples of what can be done if chemists take into account these broader sustainability aspects.

LLB: That's great. Adelina?

AV: Yes, Rich, like I said, you've been there from the beginning to see it. I didn't have the privilege of seeing the first couple of Challenge Awards, but from everything I've heard, they were so critical to helping establish green chemistry as a legitimate pursuit for industry. The way that they were shaped initially by the collaboration between EPA and ACS was to really focus on what some of the key industries were and the key types of processes that needed to be improved to demonstrate how to, if you will, for others to follow in those footsteps. We've seen those be real, shining examples of not just what can happen when industry innovates, but how that translates to economic impact more broadly, and how that can translate into competitive advantage for those companies.

We have wonderful examples of companies like Columbia Forest Products that received an award in 2007 for a soy-based plywood assembly technology and then went on to really expand that, scale it. Their new products help them compete against an influx of imported products, transformed plywood production, and so on. I can name many more. Eastman Chemicals has been recognized similarly for their GEM[™] technology, which saves energy and has been critical for improved quality and yield in their environmental footprint of some of their polymers. We've had Codexis, we've had Merck, companies that have won many awards over again and again and have demonstrated that not only is this feasible, but it's economically beneficial, and it can be recognized by the consumers as a way to distinguish the product on the shelf from others and to demonstrate that there's real benefit long term for the company to have this type of recognition.

We can point to many different players in many different industries, but what has really stood out to me is how much these awards are cherished. They're like the Emmys of green chemists.

LLB: No, they are.

AV: Although I'm not sure, Emmys, Academy Awards, but there's more there. For the winners of the last few years, when I've had the pleasure of overseeing some of the ceremonies, it's been somewhat life-changing for some of these companies because they've been so passionately pursuing a technology for a number of years, and for their teams to be recognized in this way gives them the real momentum to continue forth and the real recognition that they deserve.

I think they still play a critical role in how we need to continue to incentivize green chemistry, and I hope that they won't be the only incentives going forward, that we'll continue to strive for other policy-based incentives for green chemistry that lead to sustainability. But for now, we want to strengthen these awards as much as possible, make sure that they're broad enough to recognize the types of innovations in new industries that have sprouted up that didn't quite exist in the late '90s, and that they also embrace that connection between fundamental research and application.

LLB: Perhaps in that regard, Adelina, you can tell us and our listeners a little bit about how there are even greater opportunities for participants competing going forward. We understand, for example, there are several new categories? Maybe our listeners are unaware of the developments in this area.

AV: Yes, I'm happy to share more about that. This year, ACS has substantially broadened the scope of the Challenge Awards. We've introduced, as you mentioned, Lynn, new categories on circularity, on energy-related material design, on biomass valorization, and on safer and degradable chemicals. There are now dedicated tracks for small business, for climate impact innovations, for academic fundamental research. What this means is that green chemistry innovation is no longer confined to the traditional pharmaceutical process chemistry improvements. We now embrace materials, bio-based renewables, which are a vastly growing fraction of the nominations, and even early-stage discoveries. The awards are really opening the door to a much wider, more diverse set of sustainable chemistry breakthroughs. I would invite anyone interested to take a look at our website, which I'm sure we will feature somewhere in the show notes here that provides the nomination packet.

There you can see all of the more specialized focus areas that we've introduced to help ensure fair competition, frankly, between companies that might be manufacturing a specialty chemical and those that are manufacturing a pharmaceutical. We didn't think there was fair competition in some of the nominations we'd received in the last couple of years, with a growing number of nominations from some of these new sectors, and so we hope this will help bring up the baseline, if you will, for all of these industries and provide opportunities for recognition.

LLB: Perhaps you each could share, in your mind anyway, from your different perches, what it means to be awarded a Green Chemistry Award. I know for me, each year when the awardees are announced, we make a big deal about it here. We issue a press release. We want to make sure the recipients are given their due honor, because being awarded, to me, is a big deal. You get bragging rights, you're being recognized for innovation and contributing to society, but -- that's my view. What do you think, Rich?

REE: There are a variety of benefits. The publicity is a big part of it, getting that level of recognition. It provides motivation, it can provide market advantage to be able to claim those bragging rights. One of my favorite days of the year when I was at EPA was calling the winners. After the selection was made and EPA would reach out to the winners to inform them, to let them know that they'd won and to start preparing for the award ceremony. When I was running the program, I got to be the one that made the phone call.

LLB: What a happy day!

REE: It was a wonderful day because people were really excited about it. But one story really stands out, and it was Clark, the pharmaceutical company. They'd been selected for their mosquitocide, their design of a mosquitocide delivery system, where the active ingredient, which was actually a previous award winner from Dow AgroSciences. Clark figured out a way to incorporate that into a delivery system so that the mosquitocide itself, which was highly degradable -- that was one of the green chemistry advantages of the artificial intelligence (AI) design, but it also means that you need to apply it frequently, especially for mosquitoes, which can lay eggs and breed over a much more extended period. What Clark did is they found a way, a formulation, where that mosquitocide would only be released when water is present. You could put this in a storm drain. You could put a tablet -- think

about a pool bleach tablet. You just throw a tablet down the storm drain, and when it rains and there's water there, then the mosquitocide is released by the tablet.

LLB: Oh, how cool is that?

REE: And it prevents the growth of the larvae. It controls the larvae, and so you don't get mosquitoes. It's very, very cool. The chemistry behind it -- looking at it now, it seems so simple. But it actually took quite a bit of --

REE: Elegant.

LLB: It took quite a bit of interesting chemistry to get it to work just right. I called the contact, and I said, "I'm calling to let you know that Clark has won for this." And she said, "Oh, that's wonderful. Hang on. I want you to tell the CEO." So I called -- the day that I called, they were having an all-company retreat --

LLB: Oh, how coincidental!

REE: -- to talk about how they're going to further their corporate sustainability goals. I got to tell the CEO, and he got to announce it to the company.

LLB: -- In real time!

REE: In real time. The timing was absolutely perfect for that. Right, they've built this -- for Clark and for that group there to have made this a goal, and the day that they're looking at how they're going to do this in the future to get that --

LLB: -- It's kind of cosmic.

REE: -- I mean, to this day, I just feel wonderful about being able to make that call at that time.

LLB: Your turn, Adelina. What does it mean to be awarded a Green Chemistry Award?

AV: That's a great story, Rich.

LLB: It is. It gives me goosebumps.

AV: We've cherished making those phone calls as well, and my colleague Edmond Lam, who runs the program from our side, has had the pleasure of doing this. But every year, we also realize what this not just means for the future of these companies, but how they can bring back to us a story that both inspires and teaches us how we can evolve as an industry, or in the GCI sense, as a group of industries.

We had a number of winners that took the opportunity when receiving the awards to comment on what some of the challenges that they experienced were, what their story was, of how they got there. I think that was as important to the audience as recognizing the awards themselves, because you could clearly see that we still have a long way to go in how we regulate new chemicals and how we incentivize these new technologies. Currently, a lot of the companies being recognized are somewhat unicorns in their own industries. They've overcome these challenges, with luck and with a lot of tenacity, but we have a long way to go in helping to bring that level of incentive for these new innovations.

What it meant to me to hear these award winners was to appreciate the challenges that they had gone through. As you mentioned for Clark, Rich, that was thinking way outside of the box and taking a risk on a new type of product that they weren't sure would be accepted by the market, probably, and would have the same sort of appeal to consumers. We've seen that be something that we've seen again and again from some of these winners, that they had to be quite brave and take substantial risk. The fact that they were being recognized for that technology now substantiated that risk that they took, and so that's been really gratifying to see.

I hope that will carry that incentive forward to other companies as well, to take the road less traveled, if you will, for developing products that are a few steps advanced in their innovation, not just to replace an existing bad actor chemical, if you will, but to also find a way that we could replace the need for that chemical altogether. We've seen that on the crop protection product side as one of the many examples. We see that now on the energy materials side, where we have products that obviate the need for other products that we used to need previously. I hope this continues to be the case and we continue to use these awards to really encourage companies to take that risk and hopefully be rewarded for it afterward.

REE: Let me throw one more example in. Nalco, which I believe is now part of EcoLab, was recognized for a water treatment, not just a water treatment chemical, but a water-treatment technology, where they would analyze cooling water towers in real time, and they would only inject the treatment chemicals -- the corrosion control, the scale control, and the biological control -- when the system got out of its standard parameter. It was a very different business model. They still sell the water treatment chemicals, but what they're really selling is the service. And if they do their job well, they don't need -- you actually minimize the amount of chemicals. It's hard to convince the CEO of a chemical company to say, "We're going to sell less chemical."

AV: That's a good example.

REE: But they took that risk. They developed this very cool technology, and they're basically selling the chemical as a service if they do their job well. No cooling company tower -- they don't want the chemical. They just want what the chemical *does* in their cooling tower. They want their cooling tower to work well. This system gives them that service with the minimum amount of chemical added. Changing the mindset about what your product is, is another aspect of green chemistry that the awards can really shine a light on to say, "Hey, think about your product differently."

LLB: Differently, right, think outside the box.

AV: We've seen companies that have pushed the frontiers of fundamental research and have also leveraged academic research to then have a stepping-stone, if you will, to a new technology. What I have to highlight is, in the pharmaceutical sector, the use of various types of enzymes to replace what used to be catalytic processes that were in need of organometallic complexes and other organic catalysts. These new enzyme-based catalysts, biotechnology essentially, have allowed us to now have a much more specific chemistry that is very energy efficient, usually much less solvent wasteful -- uses water usually as a downside in terms of water waste, but replaces organic solvent.

For example, Merck has been recognized 11 times by the Challenge Awards overall, but many of those have been due to the developments of more sustainable processes that were due to the use of bioenzymatic processes of this kind. This has been translated to the

manufacturing industry as well. We've had a couple of companies being recognized on that front -- an example of how we can have a new platform technology, if you will, that then just changes the landscape. It's very difficult to compete for a catalytic process that was traditional, organometallic based to compete against these bioenzymatic processes that we can now develop much faster with the use of new computational technologies to be specific for our chemistry. We also hope that the Challenge Awards help propagate these new platform technologies that can help us take stepwise advances and lift the entire baseline of the industry.

LLB: Last question on the awards. The process is self-nomination, and I think most of our listeners are aware of that, but I'm going to ask both of you, Rich, you first. What makes a strong nomination, and what are judges looking for in a nomination?

REE: Back in the days where I was *ex officio* to the judges, the discussion around the table -- there were a variety of considerations, but the first among equals was the chemistry novelty. Does the nomination describe what the chemistry challenge was and how the chemistry that's being nominated is in fact novel? What did you overcome? What did you have to overcome to implement that? That's a critical part. I want listeners to recognize it. This is a technology award, so describe the technology. You are speaking to technologically savvy judges, so be technical and let them know, "This is what we struggled with, and this is how we overcame it." They may not know about your specific sector, but they are technical. They're chemists, they're engineers, they are biologists, maybe some toxicologists, but they are technical folks, so describing the technology matters.

Then talk about the benefits, and be quantitative as you can, especially if it's already been implemented. If you've seen implementation and you've seen benefits, you've seen waste reduction. You've been able to quantify how much of a circular material you can use, how less hazardous, whatever those benefits are, again. Be technical, be quantitative. You do have to be somewhat efficient because the nomination packages are limited. It's not 100 pages; it's eight --

LLB: You can't go on and on and on.

REE: -- so you really have to squeeze it in there. But remember that the audience that you're speaking to is technical.

AV: Yes, that's a great place to start because I can attest to the current way that we put together the judging panels. They include both industry and academic researchers. They're all experts in various fields that relate to the technology being judged. One of the challenges we find is making sure that those applications also have some quantitative metrics: figures, references of environmental and economic benefits of your technology compared to incumbents. I know that's not always easy, but there's always a possibility to have some quantitative aspect of these applications, especially in terms of the processes themselves.

I'll add that one of the ways we've seen potentially exciting technologies not reach their full potential in the judging is by not addressing the elephant in the room. If you're still using a solvent that is undesirable, but the iteration of technology at this stage is that you still use the solvent, address that. Also discuss what might be done to further improve that process in the future, and recognize that toxicology will always be an aspect of the nomination, judging process that will be evaluated. Be as specific as you can in terms of evaluating what's known about the hazard of the final product, about its end of life, and potential for biodegradation and biodegradation products.

We recognize that we don't have a complete set of data -- that would be ideal -- but that's what makes a winning technology for us is a company that has gone above and beyond the basic knowledge and data gathering, if you will, to identify where their product ends up in the environment, what happens to it, and how it might affect people, animals, biodiversity. I would focus on that holistic aspect as much as possible.

LLB: Adelina, Rich and I have so enjoyed having you on the podcast and learning more about the awards, and about the Green Chemistry Institute, and mostly knowing more about you, learning more about you and your professional career. I want to thank you for your amazing contributions to making the world a better place. How can our listeners learn even more about the awards and GCI? There are documents you can point us to or websites that are relevant?

AV: Absolutely. Thank you so much for having me. It's been an absolute pleasure to share a little bit more about GCI and the awards with you.

A couple of ways I want to highlight. First, the nomination package is available through the ACS Green Chemistry Institute. If you type into Google "ACS Green Chemistry Challenge Awards," you will land on that correct page. You can also send us an e-mail at gciawards@acs.org. My colleague Edmond Lam, who's leading the ACS component of that program, does respond to those e-mails and does address some requests for personal communication. We've had many calls with potential nominees to make sure that their time is well worth it, because we do recognize how much time and effort it takes to put together this information, and we want to make that you have a strong chance of having a successful nomination.

If you send us an e-mail at gciawards@acs.org, if you have any questions, if you'd like to have a conversation with us about whether your award fits into certain categories, or how you can strengthen to improve your chances, we do our very best to have those conversations in time for the actual deadline for the submissions. I hope that what you take -- if nothing else -- away from today's podcast that we really hope to see your technologies being submitted to this program. We want to make sure they're recognized, and we'd love for you to consider some of the ways that we could help strengthen your nomination packet through interactions with us. Please do not hesitate to reach out to us.

LLB: Wonderful. Thank you for that. I also urge listeners to look at the GCI 2025 Annual Report. I just found an awful lot of really useful information and was stunned by how innovative and prolific you and your team are. It's also available online.

Adelina, thank you so much for being here. Rich, as always, it's been a pleasure. And thanks for all your contributions to green and sustainable chemistry.

REE: Thank you very much.

AV: Thank you so much, Lynn, and thank you again for having this podcast and sharing this information with your viewership.

LLB: Our pleasure.

My thanks again to Dr. Adelina Voutchkova and Dr. Richard Engler for speaking with me today about GCI and developments in its Green Chemistry Challenge Awards. Competing for an award has never been more promising.

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