

John Warner and Amy Cannon

0:04

Hello, everyone. Welcome back to the Green Chemistry Connections webinar. We're thrilled to have you join us. Today's discussion is a follow-up from last week's webinar. John Warner's Earth Day Webinar. We had a really wonderful response. So, we're so glad that so many of you could join us last week and for all of you that can continue on the conversation this week.

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We received so many questions that we just couldn't get to them all, so we wanted to schedule another time to really discuss some of these questions and have the time to talk through them with John. So that's what we're going to be doing today.

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So, my name is Amy Cannon. And again, I'll be your host in this Question and Answer time with John, the Executive Director and Co-founder of Beyond Benign, a nonprofit dedicated to Green Chemistry Education. This webinar is being brought to you by Beyond Benign, where our mission is to foster a Green Chemistry Education Community.

1:11

It empowers educators to transform chemistry education from cradle-to-career for a sustainable future. So, thank you so much for joining us again today. If you were able to tune in last week, we thank you again for re-joining us. If you'd like to stay involved and continue to engage with us. Please do sign up for our newsletter on the bottom right of our homepage, on *beyondbenign.org* and you'll be notified about any upcoming opportunities and webinars as well.

1:42

And again, if you like what you hear today and would like to contribute, then please do so by using our donate link on our homepage. As always, before we begin, we would like to review some logistics briefly. So, we're broadcasting live and recording the session. All attendees are in listen-only mode and all lines are muted. If you have a question... We are going to be reviewing questions today, but if you do have a question that arises as we're going through this discussion, then please type it into your question chat box on your control panel. We have two wonderful moderators here, Natalie O'Neill and Janie Butler, who are going to be curating and managing our questions so that we can take additional questions. We'll see what we've got time for today. The recording will also be posted on the link that you see in the in the welcome box, but also on this PowerPoint slide. You can see the recording from last week's webinar found on that archive page, as well as we'll post this Question and Answer webinar.

2:46

For those of you who participate in social media, please do connect with us on Twitter or Facebook. And also, just let us know where you're joining from. We'd love to know. We know last week we had a good number of folks joining us from all over the world. As mentioned last week, our fabulous Juliana Vidal is joining us all the way from Brazil to help with this conversation. So, please do reach out to her and feel free to tweet questions, type them in the chat box, whatever you like. But please do reach out and connect with us. Thank you so much for being part of this community.

3:25

Before we begin our Question and Answer session here today, we wanted to just get a good idea of who's on the line with us today. So, I'm going to ask Natalie O'Neil to launch a poll so that you can tell us about yourself and we can get a good gauge of who's joining us today. So that should come up.

3:57

Great! You should be able to select one or more if you don't fall into one category alone. Okay, the votes are coming in and we can see... Okay, and there we have it! Okay, so, whoops. We launched the wrong poll, it looks like. Sorry, guys. There we go. There's the one, tell us about your background. Now you should be able to select one or more of the following. Sorry about that. We've upgraded our subscription here because of the overwhelming response for our webinar. So, we're learning new things with these polls. So, thank you so much for learning with us and being our guinea pigs in this. Now, here's the poll! It looks like we have a good number of Higher Ed folks. We have actually folks across the spectrum here. So that's it. Just to give you a good sense John, of who we're talking to today, too. So, thank you so much for joining us.

5:37

We are happy to answer questions for you today. Again, as we're talking today, feel free to type them in at any point. So, with that we are going to go into some of these questions here. My first question: John, where are you? I know that you're in the house, but it looks like you're in some sort of laboratory. Can you can you tell us where?

6:09

This is Thomas Edison's lab in Orange, New Jersey. I love it! And these are all the fancy things we can do now with all of our virtual meetings and during this age of Zoom and online meetings. Wonderful! Okay, so I'm going to start off kind of with some big picture questions and it will move through kind of shifting topics here. But some of the big questions... What are your ideas about how the world is moving forward in achieving the goal of making the planet sustainable? And sort of to build on that, you know, what are some exciting things that you see happening John, and where are there opportunities?

7:09

Well, thank you. I am very flattered to be asked to answer questions, obviously. I want to give my disclaimer that again, I don't claim to have any gifted insight here. And you know, I'm happy to share my

opinions and my thoughts that I've gathered through my experience in life, but I have no presumption that I have any gifted insight or any better view of this than anyone else on this line. For us to truly be a sustainable society we need to share everybody's opinions. So here I am, vulnerably out here, telling the way I think of things, but I think everyone else's opinion is just as valid and just as important. So, I put myself out there for criticism and for acceptance and whatever, but we all need to be sharing our thoughts, not just me.

7:58

There are so many reasons to be optimistic! I think that we're in a world right now where pessimism sells. I use the concept, can you imagine if Reverend Dr. Martin Luther King got up and said: "I have a nightmare!" I would argue that the advances would have been much less, because people are not motivated by fear; people are not motivated in the way that we need them to be by bad things. Although we've got to be realistic and we've got to understand the real world as it is, there has to be hope, that has to be a path forward. But that hope and path forward has to be grounded and pragmatic at the same time. And when you look around the world, the universities that are embracing Green Chemistry, you look at the companies that have Green Chemistry programs, you look at the NGOs that are interacting in between governments and companies, you look at the things happening in the European Union and Australia, and United States, as far as governmental policies and programs. It's slow and it takes up time... But there's so many reasons, if you want to look at that, the cup is half full. There are so many initiatives everywhere! The world is designed to sustain itself. Think of that word: sustainability. Sustained means stay the way things are. So, we kind of get to challenge ourselves with that whole concept of sustainability. Life is about changing, life is about evolution. So, sustainability itself is pragmatic, but it's a good thing because we don't want to be going off in all different directions. And so, when we look at education, when we look at industry, when we look at government, we look at the NGO community, things are changing at a measured pace. We don't want to be overly pushy because the reason we're in the situation we're in now, is because we didn't think through things as well as we could. So, say "This is the solution! Let's go do it! And do it really, really quick" is not going to get us where we need to be as well. So, this measured, patient, getting as many voices as possible into the discussion is the only true path forward.

10:25

That's great. And sort of building on that too, this is a question from last week. Is there a list of problems, problems worth solving quote, unquote, along with the value of solving them, that this is specifically asked to Beyond Benign considers important, but I would say that that you or you think the field should take note of and level of importance?

10:54

I once heard Paul Anastas say this was a quote of Jerry Garcia of the Grateful Dead. People say, "Oh we should be the best that we should be, we should find and just always push to be the best we should be", but Jerry Garcia apparently had a different view and it was that we should find out what we're uniquely capable of doing that other people can't do and won't do if we don't do it, and try to identify that. So, from

that perspective the diversity of what we want to do, what's important to us as individuals, is if we've got enough people, got enough eyes, if we can enough ideas on this process, we can imagine that everyone's going to be covering different aspects of it. And so, we need to be mapping it out. We need to be looking what everyone is doing and interestingly enough, what we need to find out is, once we see what everyone is passionately wanting to do, see other gaps, other missing elements and to make sure that we're filling them up. But again, I feel that obviously toxics in the environment is usually important, global climate change is massively important, and plastics and non-degradables in the environment is massively important. From these perspectives, everything is important! And someone who has a unique skill to work on climate change, should work on climate change! Not work on toxics because "I think toxics are more important". So, we need to match people skills and their desires with the needs of... Man, do we have a lot of needs and problems out there, but we also have a whole bunch of skills and abilities too. What we need to do is, yes, it's good to hear these prioritize lists, but the most important priority is what the individual wants to do, what each individual person says "I really care about this and I am going to spend my time doing this" and very rarely if that could it be an inappropriate thing to do. All right, that's great. That's a great point. Since we're since we're on this sort of bigger picture, I'm going to take one question that just came in. This is from Avatar out in York, England. So, thank you for joining us: "John great webinar last week. With green chemistry now 25 years old, what's your revised definition of Green Chemistry now that we have sustainable chemistry bringing in its own flavor?"

13:36

I wouldn't, you know! And I'm not approaching it from an egotistical perspective. I'm not saying that Green Chemistry is perfectly defined. It does work! But the thing is that, as you know... When we first started the field of physics, if we did that, obviously the field of physics continue to evolve, but physics is still physics; the field of biology is biology; field of chemistry, chemistry; Green Chemistry... While there are other nuances and aspects that come in to create a greater collaboration and a greater community, what we need to resist is going back and redefining the field. There are people who have written textbooks right now, there are over 20 conferences that are happening constantly under the umbrella of Green Chemistry, there are over 50 textbooks that have been written using the current definition of Green Chemistry. While there are other problems and things that get measured in, what we can't do is tear down that. There are universities now that have Green Chemistry programs. We don't want to suggest that this field continues to re-evolve and change at some fundamental level. That basis of we need to design materials and processes that reduce or eliminate the use of generation of hazardous materials kind of works. Now when we add sustainability what we're really doing, we're saying "Well, what do we really mean by hazardous?". When we talk about circular economy, "how do we achieve these goals? " And so, I don't feel that this is a definitional semantics thing; I think it's trying to understand how it all fits together. And so, I feel very strongly that when we spiral into definitional things... Frankly, the world needs us to actually do stuff, not focus on definitions and semantics so much. So, yes, it's great to characterize and to look at how we can work together and do these things, but let's put it in perspective, there's a lot we need to do. So again, I'm comfortable with the definition of Green Chemistry as it is, and I hope the webinar

last week showed how Green Chemistry fits into with the circular economy, with sustainability, with biomimicry and that is not a definitional issue as much as it is how does it fit together.

16:07

That's great. And I think yeah, it seems like, after I was trying to get it as he mentioned, you know, the sort of he agrees with the definition of Green Chemistry and then we can't tear down 25 years of this work. But I think it's convincing policymakers and this discussion that's happening in the policy world with sustainable chemistry.

16:32

And again, just the push back that society is going to give goes back to the word “sustainable”. And again, it's an important word. I would highlight actually argue: Are we using the right word when we say sustainable? Because that is maintaining the status quo; it is government policies. There is an inherent nature to try to define what we are doing today at fitting some new program, so we don't have to allocate new budgets, we don't have to allocate new programs. In a way, there is always going to be a push back: How can we redefine Green Chemistry to meet exactly what we were doing yesterday so we don't need to change things? How can we sustain what we were doing yesterday? **There's this dichotomy, there's this tension that we have to acknowledge here, that we need change. We need change in how we do chemistry, how we teach chemistry, how we invent chemistry, and how we manage chemistry; and so ironically we need to change so we can sustain.** That's great. I am going to jump a little bit, but I think we're going to come back to some of these points and I'm just going to share my screen for this question too. So, this is one... We received a few questions on this point that you make often on cost. So, I'm pulling up your slide for a reference from again, last week's discussion. I think I'll just put it on this one. I'm also guilty of actually of stealing this slide because I do think this is for some of my presentations because I think this is such an important point. But when you talk about cost being paramount, to have a true Green Chemistry process, is it price or environmental cost? Because I could understand spending more money for something that has less impact on nature. So, I wanted you to talk a little bit about this cost point.

18:37

I don't want you to call up the slide, but there was a slide that I showed before, last week, in which I had behavior in one direction, and I had technology in another direction. **For us to move to the future that we want, we need changes in both behavior and in technology. The more help we can give behavior with technology, the better; the more help we can give technology by changing behavior, the better.** So, I just see a as a default assumption that, as we invent new technologies, the more appropriate the cost is, the easier it is to be adopted. The more difficult the cost is, the more expensive it is, we run into problems first with: Will people use it? If we mandate it through regulatory processes, in a hypothetical case where the president of the United States changes and re-evaluates environmental policy, that all comes down like a house of cards. True sustainability of maintaining such an approach to build a future is positive. If the cost, economic cost, and the performance are at a high level, we won't be dependent on other constructs on society. Now that's not saying we don't need those constructs, that we scientists will not be able to. We

can't snap out our fingers and do this tomorrow! The field of chemistry has been around for 250 years or more depending on how you look at it. Green Chemistry has just been around for a couple decades. For us to expect that overnight, we're going to make things that are cost-effective, high performance, and "oh by the way" better for human health and the environment? No way! We will have some technologies that are a little bit too expensive and we'll need some behavioral modification changes from the government policies, incentives or other kinds of consumer pressures.

20:42

We will need that for the rest of my life for certain. But the idea is to look at the goal. The long-term goal is to have the technologies be sound, be good for human health and the environment in its inherent way, and not to be dependent on these other constructs to help them. This is job security for inventors around the world for decades to come. But to acknowledge, that is the best way to go about it. However, in the interim, we will always be looking at the other ways to help facilitate that. Now, when it comes to environmental cost that is part of the whole definition, I would say, of impact on human health and the environment. Cost, when I say cost it's the economic cost. But there is no way that I would define something as Green Chemistry that had a problematic cost on the environment and human health. So, I see that as built into the fundamental assumption that, when we're looking at human health and the environment, those costs supersede everything else. *Yeah, that's great. And I think you kind of touched upon this second question on cost. You mentioned a couple things in your answer here. So, you might have answered it.*

22:06

But you know cost is going to be a big deciding factor in whether companies are going to adopt Green Chemistry. So how can they be convinced, or maybe it's some of those incentives that you mentioned, that it will be cost-effective and worth it to invest in such technology? At the end of the day... When I answer a question like this, I want to make sure that you understand. I wish the world was different. I wish that consumers, that retailers, that manufacturers, that people just got it and did the right thing. But again, who among us is capable of defining exactly what that right thing is? But having said that, I'm also the pragmatist that that's not going to happen. It's not going to happen as fast as I want it to happen. So, from my perspective we need to help drive it, and the most important for us, I think is the consumer. I think that the consumer... If people aren't buying a product because it's problematic for us, sustainability, human, health, environment issue, and those sales go down, all of a sudden you will find alternative technologies that might be a little bit more expensive, but a little bit more palatable. So, at the end of the day, one of the issues that we have is this thing called "voice of customer". A lot of organizations, a lot of companies want to serve voice of customer. And the funny thing is that, when it comes to sustainability, when it comes to Green Chemistry, there isn't as much of a voice of customer. It isn't that there isn't a desire of customer, it's the voice! So, I use as an example... Having several daughters and being a fan of Disney movies, I use The Little Mermaid as an example. When the Little Mermaid is on a boat gazing into the eyes of Prince Eric, Prince Eric is saying "I want her to say she loves me." Okay, but wait a minute. She clearly loves him, but she's not saying it, she's not articulating it. So, the idiot is waiting until she actually

articulates it. Well, when it comes to Green Chemistry, of course consumers want to have something that has minimized impact on human health, the environment... Of course they want things that are sustainable. The problem is, we don't know how to articulate it well. And so, voice of customer presupposes that that articulation is going to happen. Now the thing is, there is the desire, but we're not mind readers. And there becomes a gap in this process because of it. Then the second part, you can say to me "Well, John actually voice of customer doesn't drive everything! Many breakthrough innovations did not respond to voice of customer. They came from some other place." I like to use the Disney movie Frozen for this one here. You've got Elsa. Elsa has this amazing power, but zap! She blinds her sister. Zap! She makes this freakish snowman. She hasn't really figured out how to use this power and I would argue, we chemists haven't quite figured out how to use the power of chemistry to do Green Chemistry, because universities are not training chemists to understand implications on human health and the environment. We have an inherent ability, but we haven't owned it and we haven't trained it, robbing us of true breakthrough technologies by most people, because they haven't been given that training and refining. So, we don't have voice of customer, we don't have as much of an ability for breakthrough technology, if we want. This isn't a problem, we shouldn't despair; this is an opportunity. So, here a past. Forward, the behavior working on voice of customer and then the technology working on the ability to deliver breakthrough technologies; back again to behavior and technology. They've got to go hand in hand.

26:24

I think this next question, because is sort of staying on this topic of industry, and you were mentioning the breakthrough, sort of those transformational technologies... I think this one speaks to that. How do you reconcile the fact that a new technology brings its own set of issues and at the end of day might be just as resource intensive as the original technology? So again, it's like that trade off, either the benefits of drop-in replacements versus transformational technologies, and the challenges.

26:53

Well, again, there's something buried into reality, when someone says something and sustainable but it's not. If someone says something is Green Chemistry, but it's not, it's almost.. So, to me, if it's sustainable, if it's green, it is. If the technology reveals itself to be no better than the incumbent technology, then it wasn't great. And so, there's a circular definitional loop, we're stuck in there... But again, that comes to the skills of the individuals, the people that are designing the technology, that are inventing the technology. If they don't understand the principles of Green Chemistry, if they don't understand those things, there is a very good chance that they will think they're making something that has some advance, but then at the end we'll say, "Oh man! That really didn't have any of this." That's why we want people to learn Green Chemistry, that's why we want this to be a fundamental component for it means to be a chemist, to be a material scientist. If this is part of who we are as a culture, then those kinds of problems... They won't be avoided completely. We are humans, we are fallible, we will screw up. But the more knowledge we have in our education, the better chances we have that will avoid those problems. At the end of the day, if we're as good as we're trained to be, and we're determined to do.

28:26

Thank you for always bringing it back to education. We're going to get to some of those questions a little bit later too. One more industry related question that just came in from our friends in India. Hello Nitesh! According to you John, what are the top three barriers to adoption and implementation of Green Chemistry in industry? I know sometimes you don't like to think about barriers, so maybe it's an opportunity.

28:50

Well, I will say the following: Invention, invention, and invention! Being kind of funny there, but maybe to me, not to you... But for me, if I invent a new technology that has nothing to do with sustainability, that has nothing to do with Green Chemistry, it's just a new technology. Nowhere in history did an incumbent technology lie down and say: "Take me, I'm yours!" The status quo has a magical way of pushing back. We were manufacturing vacuum tubes years after the transistor was invented; people were manufacturing horse and buggy cots after the automobile was invented. There is a process by which those things in society, whether natural or human, will have a way of clinging to a sustaining. So, when we invent something, that invention, irregardless of performance, with respect to sustainability human health and the environment, is always going to have push back. It's just a natural feedback loop of that. Now, we in the sustainability community, we in the Green Chemistry community, hope and dream and wish that, if a technology has a sustainability bent to it, it will have an even better chance of competing with the incumbent technologies. I would like to believe that at some of them to some extent that is true, but that's where behavior comes in. We still need to motivate and get that behavioral perspective a little bit stronger from the consumers, from the retailers, and from the manufacturers. The first barrier is essentially the traditional barrier that all new technology face, independent of sustainability. The second one comes back to education: Do the scientists have the ability? Do the engineers? Do the material scientists have the knowledge to invent that technology in the first place? First is the inherent push back, the second is the actual capability. I use as an example: My daughter Natalie is in the other room behaving herself very, very well during this webinar. So that's very good so far. Hopefully she doesn't hear me and come storming in the room right now. But, she's seven years old and she speaks perfect English. Better than me, better than her mother. She can read, she can write, but right now she doesn't really know what a noun is. She doesn't know what a verb is. She doesn't know sentence structure. She doesn't know things like the parts of speech. Now, pretty soon, she's going to start taking classes to learn these things and you can say, "Well, why bother? She's already reading, she's already writing, she's already doing these things!" But I would argue, for better or for worse, she's mimicking her parents in her environment and she's getting by. But when she learns sentence structure, when she learns parts of speech, she'll internalize that knowledge. She'll operate at a much higher level, not just with how she communicates her thoughts to the outside world, but how she shaped the thoughts herself.

32:30

So, the transformation from before and after is going to be kind of amazing. I would argue that we chemists are kind of my seven-year-old daughter speaking English. Of course, we wake up in the morning saying, "I'd rather not die today". So, when I go in the lab, I'm going to make decisions to hopefully prevent that

from happening. And companies, the really smart companies, found out a long time ago that if you kill your customer that's very bad for sales. So, they've learned to try to avoid that where possible. I would argue that, the desire to make safe products that don't hurt the human health and the environment has been around since the beginning of time. It's common sense! But like my daughter speaking English, we chemists, we need that sentence structure, the sentence structure in the semantics of chemistry! The A plus B goes to form C plus D; the nouns, the verbs of how we do this at a level that achieves the goals of Green Chemistry. And if we haven't had that training, then we can't achieve that. So, the second biggest barrier after the pushback of the status quo, the second biggest barrier is the raw ability of chemists to do it. This isn't just because you want to make something safe; without the skill set that's been given to you, you can't. And then the third one, and I could go on and on, but you asked for three; the third one in my opinion is the way that we finance innovation. Right now, I would argue that, we scientists we look at rate-limiting steps. And when you look at a multi-step process you find that one step that is rate limiting, and if you're to change something you need to address that rate limiting step. And I would look at, from what I call the intellectual ecology. The rate limiting step of our intellectual ecology is the financing of R&D. Specifically the scalar, the early stage, small amounts of funding to show that something is possible. We've got a lot of ability to do that. Ironically, if you've already demonstrated something is viable and you want to get millions of dollars to set up a factory, that's kind of easy to do. It's the going from the feasibility to the prototype that is the what people refer to as the valley of death of all technologies, sustainable or not. And so, if we can re-examine that financing investment model and have that favor those technologies that are sustainable, green, and benefit human health the environment climate and all of that, then we can truly make changes.

35:09

And right now, I would argue, education is evolving; I would argue that industry is evolving; consumers are evolving... The slowest thing to evolve for my perception in this, is the investment models. We're still using the same investment models we have in the past, and until that changes substantially to favor technologies that have better implications for human health and the environment, we're going to be still stuck. So, that I would say is the third area. I hope that useful. *That's great. And I love that you started with invention, invention, invention, because you're in the perfect lab for that over there, in Edison's lab. If you joined late, that's where he is, in Edison's lab. Right down the street from Seton Hall, I believe right David? Okay, so I'm going to shift a little bit over to sort of current topics today. We got a lot of questions on our current scenario that we're in with COVID-19. So, I'm going to kind of start... And then they also relate to some of the sort of bigger picture questions that we're going to get you to so, how do you see Green Chemistry playing a role with the changes we're experiencing during COVID? It's really interesting to see that some of the impact in the reduction of transportation and daily life and that sort of thing, where we're seeing some clearing of smog in some areas. Are there any opportunities here during this time? How can Green Chemistry play a role?*

36:43

Well, you know, it's interesting... Obviously this is a global pandemic that has just horrible implications for so many humans, for so many people that are suffering, that are struggling in some way. We feel bad about being locked at home and they're people that are suffering far worse than being stuck watching TV and reading books. The suffering of the human population is not to be underestimated. So, I stopped by just saying that I'm a very lucky person, that I'm in a position where although, I'd rather my world be slightly different, it's not so bad. It's a nice people to hang out with here. But it gives us an opportunity to pause. Think of the field of chemistry of going in the lab, in pouring beakers and flasks. Around the world, right now today, university students, university researchers, industrial researchers have had to stop. They're not in the lab. They're not doing chemistry. And in a way, from a Green Chemistry perspective, that's what it's all about! It's before you do something, think about it! What are the implications before I rush into the lab and I pull beakers and flasks, run an analytical experimental, run a p-Chem experiment, or do some kind of a polymer synthesis, or design a new product... Well, whatever I'm doing to push materials into the economy... If I stop and I think of: What am I doing? How am I doing this? What are the implications? That's what we really need to do. In a way, what this epidemic has forced us, is to not be wed to the elevator pitch. Think of the destruction of our society, the elevator pitch. If someone says, "Okay, I want to do something. I want money to do something" and you only have two minutes to describe it. Well, the most important things don't bubble up to those two minutes. So, no one has an opportunity to say, "Well, wait a minute. Did you think of the toxicity? Did you think..." Oh, well, that would have taken me four minutes, while we only had two. Oh my God! Can you think of the implications this has? "Rush! Harry! Harry, get along an Excel spreadsheet. Give me again! Shot it! Do it! 2 minutes! Or I'm going to work on something else!" Now all of a sudden, we are forced to stop for us to think. And maybe hopefully a lot of us are going to like that, [because thinking and imagining things before you do is the key to not making the same mistakes that were made in the past](#). And so, if there's a silver lining to this, this process of talking to one another before we're rushing out and doing it. Maybe something can get maybe... To use a horrible word, maybe that's contagious. All right, but that I see as the higher-level thing, when we drop it down to actual technologies. I think we do need to think about, in a way of the first principle of Green Chemistry: It's always better to avoid the problem in the first place, an ounce of prevention being worth a pound of cure. That's why we're isolated. That's why we're doing all the things that we're doing is, trying to prevent the propagation. At the end of the day, that's what Green Chemistry is all about. So, if we think of that bigger picture and reduce it to how do we look at surfaces, and cleaners, and products and how to stop thinking about this new layer of... When we talk about protection of human health and the environment there is this new it's always been here. This is something that people have known, and this pandemic has brought it to the forefront, but the propagation of these type of viral, microbial things. This is something that's going to happen.

40:50

If you listen to Bill Gates, this is something that's going to happen more. And we need to be equipped as a research and science community to find out ways to stop the propagation. There's going to be the medical cures, there's going to be the medical things to inoculate, to immunize and to cure. But we material

scientists have a role to play to minimize the dependency on those technologies as well, and to anticipate future issues. Yeah, and at the same time, do you see that with this time there's going to be challenges... This relates to another question that came in about: As we come out of the COVID-19, out of this pandemic, there's going to be a great need to kick-start the global economy. So how do we stop negative chemistry from being used as an excuse for rebuilding the global economy?

41:41

I feel like it's not just applicable during this time. This happens a lot. How can we avoid that sort of justification of going back to sort of traditional chemistry as opposed to moving forward? I think that's a really good point. And again, remember that I certainly don't know all the perspectives of the world... I've looked at how a lot of stores... When you do go to a grocery store once a week, hopefully keeping it to a minimum, they are no longer allowing you to have reusable bags and they're insisting on single use bags in the stores. So, one, I'm not going to argue with the wisdom of that right now. It is what it is, but that has set us back a little bit.

42:33

Again, like I said, I suspect that the wisdom of these decisions are justified, but now we got to have to come back out of that again, and maybe we need to imagine: Okay! So, we've just added another criteria to a sustainable technology. So, if we have a reusable package, how can we design? How can we invent? How can the invention community out there look at a reusable surface and make that reusable surface just as good as a single use material, so that the next time this happens, we're not going back to single use materials, but have surface treatments that are antiviral intrinsically, and thing like that? That's another technology hurdle that we need to be addressing again to stop the propagation of the virus... In addition to the medical responses we need to think of the material sciences responses. Yeah, that's so you answered the next question. I was going to bring out that sort of compromise in the single use plastic challenge that's coming up.

43:34

It's for not only infection control, but food safety, you know, and so... I had a visitor. So yeah, it's an interesting scenario I think, and I think this is going to jump over a little bit over into some of these big sustainability challenge areas, like ocean plastics, and things like that. There was a question on encouraging... It's this question of plastic use in food safety, and particular single-use plastics. Why can't we encourage industry to go back to using glass for food and beverage packaging, and where's that compromise? But not just glass, I think it's other technologies. I would build on that.

44:28

Well again, there was a time before petroleum, where all materials were bio-based. Okay, we made our cloth bags, we made all the materials, and we've made this differentiation of the plastics economy versus the bio-based economy. And I think that one thing we've got to recognize is, for the vastly foreseeable future, it's not an either/or; that we have a certain dependency; that until innovations and creativity bring

us other ways of doing things, we're going to need a little bit of both. How do we address these issues from a behavioral perspective so that we aren't dependent solely on single-use disposable items? But that would require behavioral changes going back to things that we used to do before. But they were heavy! Glasses, heavy! So the transport of glass requires energy. Now we have problems with climate change and carbon utilization and whatnot. So, these constraints... I don't see them as being insurmountable barriers, but that is where innovation has to happen. And if we have a large community of people saying "Well gee! Let's go back to glass! Glass is really heavy. We don't really want to do that." Well, then what do we do it? I cannot believe there is not an answer. We just haven't figured it out yet. So, the thing is what do we do until we figure out better technologies? We will be dependent on behavioral things... So, that's where the organization's, there are a lot of companies that are using materials that we may say, "Ah! I wish they weren't selling that product! I wish they weren't using this material!" But until, we have invented technologies that can replace those problematic technologies, we kind of got to keep using them. And so, then we want to have the companies that have really good internal policies, that have really good programs to make sure that, if they are using things that we wish there were better alternatives to, that they have the right, responsible care, and all these other programs to make sure that, when we do have something less than ideal on the market, that's in commerce, that we we're doing it responsibly. That's where we need to recognize those companies. Don't give them a free pass. Don't say, "Okay sell the problematic technology for the rest of your life". No! We've got to constantly be working on alternatives. [But let's also recognize that invention takes time. It doesn't fit on a Gantt chart. We can't say, "Next Tuesday at 2:30 we'll invent an alternative to this material". It's something we've got to add the community and the society work to do. So, how do we get from point A to point B? Through education. What do we do in the meantime? Make sure that our policies are in place that, when we are using problematic materials, we're doing the best we can with them.](#)

47:48

That's the dichotomy! If we could invent a time machine and just fast forward 50 years... Well, then hopefully we're looking back saying "Oh my God, this is... Thank God we've invented all these technologies!" But we got this path between point A and point B that's going to require a lot of different perspectives. I'm going to take a question that just came in because I feel like it's related to this conversation. At last seminar, you mentioned using a hermit crab strategy of not necessarily building something new, but taking something that already exists. So, what do we do with our old shell or the things we've already made? The old shells, if they have use... [Again, the highest level of sustainability is to keep something with the same composition and the same form.](#)

48:45

So, remember this, the way that I separate things as to, what the thing looks like, what is the shape of the thing and what is the composition of the thing. And as long as we can keep things in the same form and the same composition, then the energy inputs, for the most part, will be the best that they can be. So, looking at reuse of materials: If you have a shoe box and you take that shoebox, and you instead of going and buying a special decorated box to put photographs or knickknacks in, you use a shoebox. That it's

kind of like the hermit crab, you took the hermit crab out, and you put a bunch of photographs and things like that. Right now, companies making boxes that have their products in them... if we can design it that way too... So, the way I look at this is, we oftentimes, this is in most part, not a hundred percent, but for the most part what this question invokes is the concept of packaging. That we have this separation; there is the product and there is the package. The package is designed to protect the product from the environment, and also sometimes to protect the environment from the product. But we look at it as two separate things. The hermit crab is the squishy thing and the shell is the thing that it goes into. But interestingly enough, when the hermit crab gets too big, its package doesn't get thrown out: A new hermit crab comes in and uses it. So, I would argue that the package is just as valuable to the society of hermit crabs as the hermit crabs are. The package isn't seen as throw away but rather has in itself intrinsic value. If we can look at our products and say, "Man, I would buy this product just because of the package and I want to use that package!" Right now, that's laughable for most of the products that we get. The packaging is just... What are we going to do with it?

51:00

But if we can rethink packaging to have intrinsic value in and of itself and that people say, "Oh my God, I would spend money for this package!" because the package has other alternatives, that's the first step! It's to rid ourselves of this concept. If you think of human body... Is the brain very important? Oh, yeah! Is the stomach very important? Well, yeah! Are the lungs very important? Is the liver? But when you go through that list, very rarely does anyone ever talk about the poor skin? The skin is also a very, very important! Our organ would be a puddle of goo if we didn't have our skin. Our skin is our packaging. And if we're going to be more like biology, we've got to recognize that the package and the product are on in the same, in the future for us to be truly sustainable. That's kind of the way that I'm looking at it. But right now, it takes innovation! Not just chemists, but product designers, people that want to invent the next product need to be working with the chemists, with the material scientists to invent materials that enable that kind of use and reuse. We're not always going to get it right. We're always going to have entropy rearing its ugly head, pushing us down to materials recycling and materials metabolism, but it's important to be focusing on finding a way to have that use and reuse be designed in as part of the inventive process. Yeah, and I feel like this relates to some of the... We got a few questions on ocean plastics. It's because it's one of those big issues that's in the news these days. So, there was a few last week on this, talking about microplastics the challenge of that, how we're going to get beyond that... And there was some also interesting questions about what to do with, can we reuse plastic? I think what they're trying to get at, is what are our options to sort of design our way out of this issue of ocean plastics, and what are the ranges of possible solutions and how can Green Chemistry really play a role there? Okay. So just off the top of my head, I'm going to parley for The Oceans, amazing organization pushing this. The Ocean Plastics Leadership Summit, amazing organization. The Alliance and Plastic Waste, great group of people. These organizations that are coming together to try to address this issue. And they can look at the entire lifecycle and try to find ways to induce and encourage behavioral modification, or we can look for Green Chemistry to invent new technologies that make that whole process easier. So, when it comes to waste in the environment, plastics and other things, there is getting that stuff out of the environment, that's important

task; there is preventing it from ever getting into to the environment in the future; but then the third thing, we talked about this last week, is we Green Chemists have to say, “Okay. There's going to be leakage. Stuff is going to get into the environment. How can we design it, not to promote and suggest that people intentionally throw things out, our economy needs things to stay within our commercial loop that we're trying to design; but if it does get out, how can we be confident that it's not going to hurt human health and the environment?” If a tonka truck comes through the middle of the town and it tips over instead of getting body bags what if we just got a broom. All right, that's where we need to be thinking. Accidents will happen, things will leak, and so for the future truly be where we needed to be, it can't be, “Just as long as people behave exactly the way they do. No accidents ever happen. This is going to be great!” **but to design things so that it tolerates those unanticipated things. That's true Green Chemistry.**

55:15

That's great. And so, shifting onto another big global sustainability issue. I know we're coming up to the end of the hour. So, I wanted to get to one of these questions and then close up with a little bit of focus more on your education points. I wanted to touch upon because we got a few on climate change, because again, that's another big hot topic that's it's clearly top-of-mind for us. We've got a few questions, but what are some ways that Green Chemistry can address climate change? So again, climate change is built into the principles of Green Chemistry in several different ways. The bottom line here is that, when we look at energy utilization across all of the processes... If you think of lubrication, in a factory when you have gears turning, when you've got things happening... We're looking for bio-based lubricant something here, but we also need to improve the efficiency of the loss of energy from potential and kinetic energy and entropy loss. There are certain things that we still need to invent to minimize the waste of energy. When you think of any kind of a process in which you have to dry something, where you're evaporating either water or solvent, when you're filtering, when you have vacuums, when you do... All the things in industry that we plug in to do... **We need to invent, either the chemistry to not require those energy inputs, or to design better systems that more efficiently do those transformations using less energy.** I would argue that global climate change in Green Chemistry is kind of the top of the list. It's just something that we often tie to Green Chemistry, because the focus often times looks at toxicity, but arguably only two of the principles of Green Chemistry are about toxicities. And so all global environmental issues important. It's just the language and the discourse often time focus is on that more problematic scary stuff about toxicity, but Green Chemistry has to... It's really simple. If you believe, if someone believes, everything that needs to be invented has been invented, we just have to use it. In my opinion you're wrong and we need still inventions. These demonstration things that you may work at scale may not work at scale.. But at the end of the day we need to invent the technologies to enable a reduction in CO₂; not just by policies, not just by encouragement by government policies and incentives and things like that. But if we're going to leapfrog this, it's going to be with technology as well with behavioral changes. And man, do we have a lot of work to do.

58:32

So, we're at the end of the hour, but I wanted to read a question that came in because I wanted to sort of close on this, on the education point because I believe you think that's quite important. Thank you for that. But we did get a few on education, and there was questions about how you teach creativity. There is one, and I think that speaks to your point around invention too as well. What are the short- and long-term objectives...? This is the one that came in today. So, thank you for this question. What are the short-term and long-term objectives that a chemistry graduate can keep in mind for shaping a career in Green Chemistry and also contribute to the environment? So, a couple important questions... I'm going to start with creativity.

59:30

I believe that babies are born with incredible creativity imagination and the innovative spirit. Unfortunately, right now, our academic structure robs them of that. They walk into school the first day believing they can do anything and then they're taught that they can't. And so, [when I hear about how do we teach creativity? How do we teach innovation? My first response is: Let's look at the academic system and find out where we are robbing them of it and stop robbing them of it!](#) It's almost like having a university give a class on how to avoid student debt! There's certain contradiction in that whole process. So, I feel that what we need to be doing is to be looking at the infrastructure aspects. We are too focused on the precedent? And having this overemphasis of knowledge of the precedent has meaning some kind of an academic skill, that the individual beliefs, the individual thoughts are just as valid. We need to have some way of supporting it. Of course, you need to understand precedent. Of course you need to understand what people have done in the past, but only as part of the tool of looking into the future. I think creativity and innovation is not something to be taught; is something to not be removed from people, because everyone is already born with it. Now, when it comes to, you've got a graduate student that's passionate that says, "I want to dedicate my life to doing the right thing, to focusing on this thing", my advice is: Then do it. You don't look for a company that's going to let you do it; you refuse not to do it. You don't go to a university and say, "Oh, I want to get tenure, so I'll pretend I don't do this until I get tenure." Oh my God, if you don't know university that you have to fake who you are to get tenure, then you are at the wrong university.

1:01:26

[We need to embrace this thing and just refuse to not be who we want to be.](#) So, this is not something that... Of course, hopefully some day in the future, we have a universal environment that supports this perspective, but we don't have that today. And so, we're going to need courage and strength of people to refuse not to do this. I wish I could have advice and say, "Oh, go work for this company because they want you to do this!" Then we're robbing ourselves about future and you need to be, again to use this horrible analogy of the times, you need to be the virus to infect companies so that, they without knowing it, become green and sustainable. [And so please by all means don't just look for the comfortable path. The path with the most resistance is probably the most meaningful.](#)

1:02:20

I love that. I kind of want to close on that point because I think that's very good. To the questions that we did not get to that came in today and from last week, we will post responses to those along with this recording. But John just in closing, what question have we not asked you or are there key points that you would like to share with the closing thoughts today? Well, I think that at the end of the day the most important thing is to recognize that everyone's thoughts, everyone's ideas, everyone's passions are valid and important. And to say, "Man, this is what I like to do. This is who I am!" Find a way for that to be the path to the future that you want to give. Don't look at having that be absorbed or inherited from somebody else, as much as being the driving force itself. There's a lot of resources out there to help, shameless plug for Beyond Benign. The website Beyond benign has amazing resources for K-12 educators, university educators, the developing industrial training aspect to Beyond Benign. So, that is one of many other places. But seek out to bring those resources to yourself, don't look for the world to give you those resources; seek them out and insist on them. This can't be achieved passively; it has to be an aggressive insistence of not doing it any other way. And there's nobody on this webinar, or in this field, or in the world that doesn't have the ability to do amazing things. So, let's just do it.

1:04:16

Completely agreed. Thank you so much John, for your time, and your passion, and all of your answers in this discussion. Thank you all for joining us. Just in closing, I'm going to share my screen here. We do have a webinar tomorrow, particularly for our Higher Ed audience. So, please join us if you're able to tune tomorrow on this. Wonderful tool from MilliporeSigma DOZN 2.0 and how we might incorporate that into our teaching and courses. So, that's tomorrow! Just again a final thank you to all of you for tuning in last week and this week. We can't thank you enough for joining in on this discussion with us. A huge thank you to John for sharing again with us, and please stay connected and please stay involved. So, thank you all. Thank you.