In These Times, Season 3 | Better Living…Through Chemistry? (Episode 5)

Alex Schein:

The vastness of scientific information can cause us to look up at the stars with awe, but can also cause other reactions like skepticism and disbelief, denial, and discomfort, and even fear. On this season of the Omnia podcast, we talk to scientists and other scholars about scientific ideas that cause big reactions. We'll look at stories of science getting knocked around and standing back up again, in a world full of polarization, politics, misrepresentation, and simple misunderstanding. Welcome to In These Times, Fear and Loathing and Science.

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Alex Schein:

The phrase "better things for better living through chemistry" began in 1935 as a DuPont advertising slogan, an enthusiastic expression of optimism about science and it's potential to solve virtually any human problem. Just ask Madeleine Joullié, Daniel Mindiola, and Eric Schelter. Three of Penn's chemistry faculty who offer up their greatest hits list of chemistry's most transformational discoveries.

Madeleine Joullié,:

I think all transformational discoveries have dealt with catalysts. There is at least three different types of catalysts: organocatalysis, catalysis with enzymes, and organic catalysis.

Speaker 5:

The discovery of radiation and applications thereof. The other one has to do more with, and is also controversial, the production of ammonia from its elemental constituents. So this is called the Haber-Bosch reaction. The third one is a subject of debate, but for me, because of my passion for forensic science, is the discovery of PCR, or the invention of PCR, which is called the polymerase chain action.

Eric Schelter:

Agriculture, polymer, Haber-Bosch chemistry, refrigeration, electronic materials, nuclear chemistry, and processes, and then the chemistry biology interface. It's almost like a personal question when you ask chemists about things like that.

Alex Schein:

So why out of all of the sciences is chemistry so little understood and so often held in low regard by the public? For one thing, chemistry is hard. Some of us might have been a bit bruised or alienated by the subject after slamming up against it as a student. Compound this with something even the most passionate chemists recognize, there have been some serious downsides associated with a lot of the better things for better living that have been made possible through chemistry. In this episode, we'll be talking with Eric Schelter on chemistry's public relations problem and why we need to put our faith in chemistry now, maybe more than ever. Welcome to episode five, Better Living Through Chemistry.

Alex Schein:

If you're a chemist, you're probably energized by the ways that discoveries in your field continue to transform how we live, but you also might find that you have to think twice before talking about your work at a party.

Eric Schelter:

Like on chem Twitter, for example, like people, our grad students will talk about how they don't tell people that they're in chemistry grad school, because it elicits some response that they don't want to have that conversation again. So it's interesting that there definitely ... If you talk to chemists, there definitely is a reaction that many people have experienced when they talk about what it is they do.

I think that people generally, I mean, when I have discussions with the general public or people, I meet at cocktail parties when I go to cocktail parties and I tell them I'm a chemist, there's always a visceral response to it, it's often kind of negative, right? And so people have a sense of what chemistry is about, but I think that they don't necessarily have an appreciation of just how much it touches their lives, right? To the extent that at every aspect of their existence, from the food that they eat to the car that they drive, has a major set of chemical processes associated with them that really have transformed society and raised the standard of living of everyone on this planet in no uncertain terms.

And so yes, it's an interesting relationship, it's an interesting dichotomy between the kind of marketing of chemistry or the reaction that people have to chemistry, and the fact that so much of society and human civilization relies on the fact that we do chemistry well and that it has transformed of the way that people live, certainly across the beginning of the 20th century and into the 21st century. And every kind of major problem that we face in society, there is a chemical aspect to it and mastery and development of chemistry is going to have a significant impact on this trajectory that civilization takes in the next century.

Alex Schein:

So why the disconnect between the fundamental importance of chemistry and these visceral negative reactions? Schelter is quick to acknowledge that along with the advances and discoveries come significant unintended consequences.

Eric Schelter:

So when chemists set out to make molecules to work on some problem or advance the field, or provide some solution to a challenge, they might not know all of the possible ways that that compound can interact with the complex system that is life on planet earth. And I think chemistry in the 20th century was about the immediacy of finding solutions to problems and to develop a discipline and take it forward that provided a lot of answers and provided a lot of ways to push people forward, right? But inevitably, and I think this is true of all science, just because the world we live in is so complex, that there are unintended or unanticipated consequences to discoveries in science, and chemistry is no different. I think in that sense, it's a bellwether as a discipline about what we're going to see from other disciplines in the next century.

Alex Schein:

Schelter notes chemistry is not alone. In other areas of scientific research, we may now be in that moment where the applications are outpacing understanding of what possible unintended consequences may come.

Eric Schelter:

So I'm not trying to be a doomsayer here or anything like that, I just think it's interesting that chemistry arose as a discipline that can really affect people's lives. It was kind of organized in a way to have a huge impact on people's lives in the 20th century, and so as new fields of science that are emerging that are enabled by the way, by chemistry and having the mastery of chemistry that was established in the 20th century, as these new fields arise, it will be interesting to see how they change humanity or what the consequences or outcomes of these new fields are. Are there things that we didn't anticipate that will similarly result? And you'd like to be in a position where you could anticipate oh, if I let this genie out of a bottle, or if I create this compound, I will know that it will have these different effects, or if I tinker with DNA in such a way, but it's unknowable basically until the technology has been used by people for some period of time.

Alex Schein:

Even knowing what we do now about unintended consequences, it's clear where the better living through chemistry optimism was coming from. The triumphs of the 20th century had an incalculable impact on humanity. Schelter elaborates on some of these triumphs and acknowledges the potential downsides.

Eric Schelter:

I think about different processes of that have had a huge impact on humanity, things like the ammonia synthesis, the Haber-Bosch process, which totally transformed agriculture. So when you can feed as many people as it became apparent that we could feed with synthetic ammonia in the early ... Out of the Haber-Bosch process in the early 20th century, that totally changed the landscape for humanity, right? People were not worried about where their next meal would come from as a result of that, perhaps the most important chemical discovery of the Haber-Bosch process for the synthesis of ammonia and that fundamentally changed the human base.

And so that's a very optimistic time where people can be fed in the post-war era with synthetic ammonia and the population exploded, but there is potentially the downside of massive amounts of agricultural runoff and just the burden that it brings to have an increased population at a high standard of living on planet earth. So it's not thinking about sustainability, it's thinking about growth with these discoveries in the sort of early and mid part of the 20th century. And in the later part of the 20th century, we become aware of some of the consequences or implications of that idea of just unfettered growth and discovery.

Alex Schein:

And then of course, there's the discovery and development of materials that literally and figuratively shape our day to day lives.

Speaker 7:

I just want to say one word to you. Just one word.

Speaker 8:

Yes, sir. I'm listening, just so you know.

Speaker 7:

Plastics.

Eric Schelter:

Another one that I think about is polymer chemistry, and so Bakelite polymer in early 20th century 1909 or so, Leo Baekeland. And so the discovery of these synthetic macromolecules, these synthetic chains of molecules that are created from smaller units that turn out to be useful for everything. I mean, polymers are all around us all the time. And so what an amazing time to be a scientist or an engineer where you have all these new materials that you can discover, go into the lab and create, and then try and figure out a way to use them or begin to classify these macromolecular species into possible ways that we can use them and apply them and make them into any kind of product that we want.

Alex Schein:

But polymers like ammonia synthesis have revealed their downside.

Eric Schelter:

And so now a lot of chemists are thinking about well, there's a huge amount of polymers, little tiny pieces of polymers, that are floating around in the ocean, and we didn't really think about that when we were doing the discovery of these materials and developing the field of polymer chemistry. And these materials persist, and this is ... A lot of chemistry in the 20th century is the really persistent compounds, so how does the natural system in interact with a tiny piece of polymer that is floating around in the ocean for hundreds of years? Can it degrade it or do they just continue to accumulate? And then what happens to aquatic life in the oceans as that material accumulates inside them? And it's a challenge. It's a problem.

Speaker 9:

It's no surprise plastics litter the oceans, but it's how microplastics enter the environment that may surprise you. That fleece washes away microplastics with every load, a tire's wear and tear deposits rubber but also tiny bits of plastics onto the road that eventually drained into waterways. Researchers here found Tampa Bay is littered with four billion particles.

Eric Schelter:

Now chemists are thinking about how can we develop polymers that are an irreplaceable part of our economy but don't persist in this way, or how can we sort of transform those materials that we created previously back into feed stocks that we could use again, right? So this begins to see this interplay or this feedback loop between the discoveries of the mid 20th century and the discoveries in the 21st century around not just doing chemistry, to raise all the standard of living of life on earth, but doing it in a way that the standard of living can be maintained indefinitely, right? And that certainly, of course, is in the context of climate change and the use of fossil fuels, which we got very good at as an energy source in the 20th century.

Alex Schein:

There is a long story that could be told about climate change and fossil fuels involving our prodigious ability to extract and consume them, but Schelter offers up a succinct explanation of where we are with respect to climate impacts and how we need to respond.

Eric Schelter:

We have loaded up the atmosphere with a significant amount of climate altering gases that are going to persist therefore, a long time until we can develop, for example, technology that will be able to capture the carbon dioxide back out of the atmosphere, which is a significant chemical problem.

Alex Schein:

And this brings us to a central paradox, when it comes to the climate crisis, we may blame chemistry for getting us here, but we also have to rely on it if we're going to get back away from the brink and find a path to sustainability.

Eric Schelter:

I mean, we all can understand why people might have this negative reaction based on an experience in their early lives, but also that that was the sentiment in the 1950s about better living through chemistry and we're seeing the impacts of sort of that unfettered growth and discovery around materials that persist in a climate that's changed. And now scientists or chemists are coming to people and saying, "But we'll have the solution for you if we just do more chemistry." Right? So it's that technocratic approach that people might not trust with science providing the solution. On the other hand, it's the only option, so I guess I'm in the technocratic camp. This is the framework for humanity to make progress.

Alex Schein:

There are some promising lines of inquiry in chemistry that Schelter feels especially optimistic about for their potential to solve the critical problems of mitigating climate impacts and achieving sustainability.

Eric Schelter:

So the ability to work on problems and sustainability and climate change chemistry is the central science there just the same. The process that nature uses to drive life on this planet, starting out from energy coming from the sun, which is captured in plants and cyanobacteria, and then initiates sort of an energy pathway across the food web and the web of life on this planet, right? Those are all chemical processes that are happening in complex biological systems.

Eric Schelter:

And so in the best case scenario, climate change needs to be addressed by, well one, trying to clean up the previous messes of the amount of carbon that we've released into the atmosphere. So having negative emissions by using materials that chemistry can create to actually capture actively CO_2 out, which is extremely challenging and an important challenge to try and turn back the clock a little bit there. But then also figuring out new ways to have our civilization powered by renewable energy sources, by ones that we don't have to rely on these fossil fuel inputs, it's cheap, but dirty energy.

And so we can look to nature in that context and see how nature captures light from the sun and uses it to drive chemical reactions, which is really the ultimate way to achieve sustainability, and there are some pretty fundamental reactions that you can identify. But what we need to do is sort of learn from nature and then adapt that to the industrial model that civilization has so that we can maintain our standard of living, but not continue to add carbon to the atmosphere.

Alex Schein:

Professor Schelter is one of a group of scientists at Penn pursuing research on these frontiers. His lab focuses on the inorganic chemistry of rare earth elements, the elements that are vital to technologies ranging from batteries and smartphones to flat screen TVs. These elements tend to be difficult to extract without causing environmental harm, and his lab has invested considerable brain power in establishing ways to recycle them. Schelter's lab also explores reactions that may help to mitigate lease of methane into the atmosphere and could lead to a readily available carbon source for sustainable energy. He described some of the related areas that are being explored at Penn.

Eric Schelter:

A lot of researchers at Penn and many other places are thinking about sort of the action of capturing solar energy and then converting it into compounds that store that energy that we would generally refer to as a solar fuel. And so some of the most important solar fuels are hydrogen gas that we obtain from the water splitting reaction, so we can take ubiquitous water all around us and develop a device, this is ultimately the dream where we can efficiently capture sunlight, energy in that sunlight, use its split water into its constituent hydrogen and oxygen gas.

So, there's actually a significant amount of research to these kinds of goals, all the steps along the way. It's a huge problem, and so it's very complex to get all the moving parts in place to be able to capture the solar energy and then direct it in an efficient way into fuels. So that's a huge science and engineering problem and places like Penn and the Vagelos Institute namely are bringing together engineers and scientists to try and promote stimulate fundamental discoveries related to materials, and also the chemical reactions and catalysts that will drive that reaction. Or let's say promote that reaction at an appreciable rate while capturing light from the sun.

So this is the big challenge. It doesn't have to be hydrogen per se or water splitting as such, but this is the reaction that most chemists think is going to be the one that has the impact in the 21st century that maybe say the Haber-Bosch process had in the 20th century in terms of transforming our standard of living. It's interesting to hear chemists talk about that. I mean, so much of life changed when in the 20th century, when those really important chemical discoveries were made. How is life going to change when people don't have to worry about energy anymore, right? Because we've figured out how to harvest as much of it as we need from the sun. And by the way, the sun provides all that we would need and more to continue to maintain our standard of living. So solving the sustainability problem is the challenge of course, of the 21st century, and chemists are going to be the ones working with engineers to develop the solutions that are going to make our civilization sustainable.

Alex Schein:

Scientists like Eric Schelter are keenly aware of the ways in which science is being currently distorted in the public dialogue, but given the stakes for our ability to address critical problems like sustainability and climate change, it's more urgent than ever for scientists to find a way to break through the disinformation and clutter.

Eric Schelter:

I think it's a big challenge. I think scientists can ... I mean, it's easy to say, but scientists can do better. They can continue to work on improving skills around communication to wide groups of people, not just other scientists in the other peer review process. And we need to learn also from other fields about how to communicate the findings of science to allow everyone to make decisions. I mean, as a chemist, I want to be able to inform policy makers, I want to be able to inform the general public, I want to be able to inform my neighbors about what it is I do and why it's important, and how the information I'm generating in my research should be used to guide people in decision making,

Alex Schein:

His colleagues in the department agree, both in the importance of the work of chemistry and the necessity of communicating about it better.

Daniel Mindiola:

There needs to be a better bridge between scientists in general and the community, because one of the factors that I found out that's difficult is to communicate to the broader side of the community, right? To the broader aspects, communicate my science, such that they can understand and appreciate it. And that's difficult, sometimes that's really difficult, and I think scientists get frustrated with that. They might use a lot of technical terms. I don't know if that's to boost their own confidence or just to show that they're smart or whatever, but I think that has to be halted to some extent. It's good to speak in those terms when we're in the lab, but when we're talking to the community, I try to ... I'm not talking about dumbing it down, but I try to make the science appealing to them so that there's a connection between what they appreciate and what I appreciate about that topic.

Madeleine Joullié,:

Today science is blamed for all the evils and it is not appreciated for the good it does, even that is suspicious. Just like some people don't believe in vaccines, right? So this is a very ... I think it's a very important problem and I think we should try to solve it, and I think it could be solved.

Alex Schein:

This concludes episode five of In These Times, Fear and Loathing and Science. We'll be back in two weeks with episode six, the Large Hadron Collider and the End of the World. We'll talk with a physicist about the veracity of doomsday scenarios associated with high energy particle collision experiments.

The Omnia podcast is a production of Penn Arts and Sciences. Thanks to professors, Eric Schelter, Madeleine Joullie, and Daniel Mindiola. I'm Alex Schein. Thanks for listening. Be sure to subscribe to the Omnia podcast by Penn Arts and Sciences on Apple iTunes, wherever you find your podcasts. To listen to all seven episodes of season three of In These Times, Fear and Loathing and Science.