[MUSIC PLAYING]

JEFFREY GROSSMAN: So we've sort of got into this place where we can make anything we want all the way to scale the atom while at the same time, we need that more than ever to solve the most pressing global challenges. It's a really exciting time to understand how atoms come together and what we can do with that.

SARAH HANSEN: Today on *Chalk Radio,* we're talking atoms. In this episode, we're going to see what it takes to bring concepts from theory to reality and how one professor at MIT has learned to make his course content real, tangible, and important to his students.

JEFFREY GROSSMAN: If you can touch and feel some aspect of what you're learning, then you learn it in a richer way. You learn it from a different angle. You see the problem a little bit differently.

SARAH HANSEN: We're going to explore the world of solid state chemistry course 3.091, which as always is available on MIT OpenCourseWare. And to take us through, we're talking with Professor Jeffrey Grossman.

JEFFREY GROSSMAN: I am the head of the Department of Materials Science and Engineering at MIT. I teach 3.091, and I do it as the lead instructor. But it's only possible to teach it effectively because I have an outstanding staff of TAs as well as a wonderful course administrator who all come together. And we give it our all every fall. So that's why the course works.

SARAH HANSEN: And this course, like many others we've highlighted on our show, needs a team that understands how to speak and appeal to a general audience, an audience that may not know much about chemistry to begin with. This course is what we at MIT call a GIR or General Institute Requirement.

JEFFREY GROSSMAN: Before a student can graduate from MIT with an undergraduate degree, they have to have taken one semester of chemistry. So we emphasize the basic building blocks of chemistry, and then we build solids out of those. And so the basic building blocks are atoms and the way atoms bond together and then how those atoms come together to make solid materials. And that's why the course that I teach is called solid state chemistry.

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SARAH HANSEN: You've probably heard of the Stone Age and the Iron Age. But what age are we living in now? Part of what makes this course so interesting and one of the reasons that I wanted to share it with you is that it invites you to explore questions just like this, questions that take a contemporary look at solid state chemistry.

JEFFREY GROSSMAN: So as a materials scientist and engineer, I love the fact that we tend to name the age we live in by the sort of material that mattered most in that age. I would say that recently, we've had the age of silicon, the age of plastics. I think that we have reached a time in science and engineering where we will never be able to do that again i.e. to name the age we live in by some single material.

And the reason is that we are now at a place where we can actually design any material any way we want all the way down to the atoms that make it up. And so that's a kind of new era. And I call that the age of materials design. It's really the age of atomic scale materials design.

There's a very famous speech that Richard Feynman gave called "There's Plenty of Room at the Bottom." And it was really the first vision of what would happen if you could move atoms around anywhere you wanted. And, well, you could make pretty much anything. And so the question then is how could you do that? And then the other question is what would you make?

SARAH HANSEN: And if that wasn't enough to pique your interest, Professor Grossman makes sure to apply these questions to the issues that affect humanity on a global scale.

JEFFREY GROSSMAN: What is so exciting about the fact that we now are able to put atoms anywhere we want, that has come at a critical moment in the challenge that we face globally in energy and climate and sustainability and many other challenges. Because at the heart of getting through and solving these really hard problems lies the design of a new material.

And so we've gotten to this place where we can make anything we want all the way to scale the atom while at the same time, we need that more than ever to solve the most pressing global challenges. It's a really exciting time to understand how atoms come together and what we can do with that.

SARAH HANSEN: To Professor Grossman, the real world applications of solid state chemistry are just as important as the theoretical concepts so much so in fact that every single lecture has an added element that explains how students can practically apply the concepts in the real world.

JEFFREY GROSSMAN: Just because I'm teaching say a lecture on the periodic table, or I'm teaching a lecture on Lewis structures, or I'm teaching a lecture on X-ray generation, it doesn't mean I can't connect in each case to some sort of bigger picture question or something that they can really connect to that is more broadly accessible.

I call it my "Why this Matters" moment because it gives context. And I think we as teachers should be able to do that with anything we're teaching. So for every single one of the 36 lectures that I teach, I take a "Why this Matters" moment. And I connect what it is that we learned right there in that lecture to some sort of pressing global challenge, or maybe it's a technology that they all know or can connect to just to give that context.

SARAH HANSEN: And as you may have guessed, the "Why this Matters" moments are a favorite part of Professor Grossman's lectures and not just for the students.

JEFFREY GROSSMAN: It's also really important for me because it makes me excited. And it makes me every year come up with new ideas for how to relate the material to some bigger picture aspect of their lives. In the first year, I actually wound up sometimes cutting that short. Sometimes I had too much material to get through in a lecture. And so we didn't get to the "Why this Matters."

And what I heard from students was how that was such an important part of each lecture that they didn't want me to ever cut it short. And so I've been very protective of those moments of class. Because as soon as I put the "Why this Matters" moment in front of them, they sit at the edge of their seats.

I feel that this is something that we could do in any class we teach. I don't care if it's some advanced algebra or a Python programming class or civil engineering. It doesn't matter. Every time we teach, I think that we can take what we're teaching. And we can try to give it some sort of context, how what they've just learned connects to something else.

SARAH HANSEN: At the heart of Professor Grossman's teaching is a focus on allowing his students to see, touch, and interact with the subject matter, to make it apparent to the senses in order to make it matter.

JEFFREY GROSSMAN: I always feel that if you can touch and feel some aspect of what you're learning, then you learn it in a richer way. You learn it from a different angle. You see the problem a little bit differently. So in the very first lecture, in fact, in the introductory lecture, I talk about how it is that chemistry came to be. What was the early goals of chemists? What were they trying to do?

And one of the things that they did is they took things like a rock and say, well, how do you break this down? What's it made of? And so they smash it, or they light stuff on fire. We don't tell our students to do that, by the way. Or they mix things together to smash it. They break it. They mix it with that. They mix it with that. And they say, well, what happens? And through that came discovery of the basic building blocks of matter.

And so what I wanted is I wanted to say, well, OK, let's put ourselves back in that position. At the time, my youngest daughter was 6. And so she had had something like three birthday parties she went to in one weekend. And so our hallway had a whole bunch of these goody bags with candy and Disney toys. And I'd look at those and think maybe we could put chemistry in these bags.

So we created a set of goody bags, about one each week. And so in the very first goody bag, I give students five different strips of something. I don't tell them what they are. And I give them a ruler to measure the strips. They can weigh them. And I give them some vinegar. And again, the idea is to try to put them in the position of, well, let me give you things that you don't know what they are. How would you figure that out?

And then gets to a really important part of the goody bag, it is meant to complement what I'm teaching by giving a way for them to touch and hold and interact with the chemistry, but it's also meant for them if they want to go beyond what we're learning and to try their own ideas out.

SARAH HANSEN: Professor Grossman knows his methods aren't exactly conventional and might not even be effective in every given scenario. But his teaching experiments are guided by strong communication with his students and a simple yet powerful philosophy-- trust the process.

JEFFREY GROSSMAN: You don't have to have everything work perfectly. But work on it together with your students. So the goody bags, I was very excited about them. But I think they really needed to be tried for a year and then to figure out well, OK, what worked and what didn't work?

And let me get feedback. And let me talk to students about it. And then let's make them better. And I think that's true every year. I always want to teach better. And I always want to get feedback and realize what doesn't work and what does and then amplify what does and add to it.

And trying new ideas out is a part of that process. I tell my students all the time that success-- this is so important. Progress has nothing at all to do with success, nothing. Progress has to do with what we choose to do with failure because that is then what leads to the success. And I try to convey that to students. And I have to convey it to myself as well, that you have to remind ourselves that we're all in that same position.

SARAH HANSEN: And so Professor Grossman continues to work on inspiring his students to explore new ways of looking at the world one goody bag at a time. He's made all of his teaching materials from Introduction to Solid State Chemistry openly available to you on our MIT OpenCourseWare website. So be sure to check them out.

Thank you for listening. We hope you're feeling as excited as we are to keep learning. We'd love to hear how you use the resources on MIT OpenCourseWare to power change in your life, classroom, or community.

You can send us an email or even call us to tell us your story. And we'll share it with other listeners so they can feel inspired too. Our phone number is 617-475-0534. And you can also find it in the show notes. Signing off from Cambridge, Massachusetts, I'm Sarah Hansen from MIT OpenCourseWare.

[MUSIC PLAYING]

CHILD: Ma, "pah-k" the "cah."