

Grow Everything Interview Transcript: Natalie Kuldell

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Natalie: I would be very surprised if 20 years from now the largest companies are things like Google and Meta—it's gonna be bio. They're gonna be bio companies. But, for us to exist, BioBuilder to exist, we need to somehow bridge that gap between what is now and what is future.

Intro

Karl: Hey Erum, how are you doing today?

Erum: I'm doing great. I am just looking at our analytics here for the podcast and wow, it looks like our cannabis episode went up the ranks, it went up really fast. It's number two. And I wonder why, like, why are people interested in cannabis? What do you think?

Karl: I think people are in, are just, inherently interested in vice. But cannabis is really interesting, because it's kind of controversial, it's been illegal for so long. States have been legalizing it. Its use has become more acceptable, can we say that? So I'm not surprised that people are interested. And that intersection between cannabis and biotech is fascinating. There's a lot going on. Since that episode happened, we saw another cannabis company that is specializing in manufacturing endocannabinoids, I think they're called Nalu Cannabis and made a big announcement. I think it's always in the news, and it's interesting. What do you think?

Erum: I think for the same exact reason, but one thing is that's because we had Seth on and he is a financial guru and he knows a lot about the market and people might be interested in getting involved in the industry and they wanted some hot tips and we definitely provided a lot of hot tips in that episode, or Seth did, and we absolutely need to get him back on. Because he has a nice voice. I would like to say, sounds like Anthony Robbins, he has like a deep voice. And Seth, I know you're listening to this and this is a compliment. I mean it with the utmost respect. We definitely should have him on for both, obviously the knowledge, but also the sound of the voice.

Karl: We will do that. In the meantime, we've been quite busy, in New York City, attending events and visiting people. so our offices at Messaging Lab are in Dumbo, and we're right next to the Navy Yard. And the Navy Yard is where New York City announced it's gonna put in a new biotech hub, which we are lucky enough to visit.

Erum: Yeah, and we were lucky enough to visit because, our friends at [TomTex](#), Uyen and Ross were so kind enough not only to show us their lab, because their lab is right

below the floor that will occupy the biotech hub. So we saw their labs and what they're working on, they're creating a hundred percent Biobased materials.

And one thing that I thought was interesting Karl, and I think we can quickly touch on this, is that we talked. the labeling of being an alternative leather and that they don't like that term. And it was interesting because when we spoke with Axel and Alexis on this podcast, and they mentioned that like the term alternative leather, sometimes I have to say that because there's some performance characteristics that are similar to leather based on what they're making. But, it isn't leather. It's a completely different material. So I thought that was really interesting that when we talked to Uyen and Ross, they brought that up as a message that they wanna change that narrative.

Karl: It is super interesting because a lot of these companies are producing, and I hate to say it, leather alternatives, but they're not really leather. They're biomaterials. The performance characteristics are very different. I think it is exciting that they can replace what leather is and what leather does and the kind of the environmental impact of leather, which is significant. It's in the top five livestock. Agriculture is for sure in the top five most polluting industries on the planet. But, I think that calling it alternative leather or leather substitute does a disservice to the biomaterial itself. luckily we're gonna have Suzanne Lee, who's an expert in this space on the podcast very soon. And so hopefully she'll give us some vocabulary and language that we can use and help people use when it comes to talking about their novel biomaterials.

Erum: Oh yeah, absolutely. And it was such a delight to see her on Sunday. To an amazing biotech event of different leaders in this space and here in New York City at the C16 labs. So we spoke with Shara, on this podcast a few episodes ago, several episodes ago at this point. And it was a great time. It was something that we co-hosted with Syn Bio beta and C16. How'd you like it, Karl? You saw a lot of your friends that you've known for quite some time.

Karl: Yeah. It's always good to see people that we know and also to bring new people into the fold. So one of my good friends, Jonathan Fassberg, who's worked in the biotech industry, for more than 20 years, has worked on the investment side, had an investor relations firm. He was there. It was his first introduction to the Synbio community. And he was really amazed by the quality and caliber of the people that were there.

We know that biotech in New York is a thing. It's a big thing. We don't really need anything. Everything is here. And the nice thing about being in New York City is that everybody eventually comes here for one reason or another, but the primary reason they come to New York is for money, since this is the financial hub of the world, but it is becoming a very important biotechnology hub as well. How did you like the event?

Erum: It was very fun. We saw many friends of the pod, so we saw Shelby, speaking of money, her episode also moved up the ranks pretty fast. Putting money where your

microbe is. That's the title of the podcast, which is really funny. But Shelby's so great. It's always a joy to talk with her. And then John Cumbers, of course, he was there and really brought a lot of people together. And I like some of the new companies that were pretty interesting that were there. It was great to see their labs again. So another friend of the pod that was there was Ellen Jorgensen and we interviewed her in the early days and we were all just reminiscing about being in the lab and all the new types of lab equipment that's there. I was in a lab years ago. Ellen was in the lab. She started years ago. And it was just great to see what are some of the new developments there. So David Heller gave us an overview of what was going on in the C16 labs.

Karl: Yeah, so David is the co-founder at C16 along with Shara and, when you walk into their space, they've got a display that shows their Palmless product, which is a palm oil alternative. And, Erum and I both picked up a bottle and we'll be doing an unboxing video, whatever that looks like, in, separate from this episode so you can see us, open the box of this material, this new oil, skincare oil, and, describe what we think about it. We'll put the details in the show notes.

Erum: I will just say that one of the things that's gonna be interesting is to talk about how the product's different, and of course we'll talk about the technology part of it, but a lot of it's going to be like educating and maybe some people don't care. Like they just care about, does it work? Is it going to improve my skin, improve my hair? But educating about how it's made is gonna be very important. And, for our podcast right now, we just interviewed Natalie and Karl. Can you tell us how you met Natalie?

Karl: We're about to interview Natalie. And Natalie is an ex-researcher, ex-MIT professor of synthetic biology who started an educational nonprofit called BioBuilder. And I honestly can't remember when Natalie and I met for the first time. But it feels like we've known each other for a fair amount of time. And anytime we go to Boston, I see her. And actually Erum, I think you may have met her too, at a Genspace event because she did do a Genspace event many years ago that I know I was at, and you could have been there too. And that was probably when I was first getting to know her. But so BioBuilder is an organization, it's also a book that Natalie published with our friend Karen Ingram that basically teaches middle school teachers how to teach synthetic biology.

And Natalie understands the importance of science education. She knows that education needs to be exciting and very applicable. I think most people don't realize that science and technology are significant drivers of the economy. So we want to always be investing in basic research. The United States used to invest a much greater percentage of its GDP in basic research than it does today.

This is something that the Chinese government learned from the US and they actually invest a greater percentage of their total GDP in science and tech education. So I think we're gonna have a great conversation with Natalie and, let's let her take it away.

Erum: All right, let's do this!

Transition

Erum: Hey, Natalie, how are you?

Natalie: Excellent. So happy to be here.

Erum: Wonderful, wonderful. So we wanted to talk to you about BioBuilder, your background, and you were trained as a researcher. You taught synthetic biology to undergrads. How did you make the transition of teaching teachers and now teaching younger students, and what sparked your interest in teaching biology in the first place?

Natalie: Yeah, it's a funny story. I never really thought I would be a teacher. In fact, I chose a graduate school that I could attend where I would not have to be a teaching assistant because I was just so sure. I never wanted to teach. So life is funny, I guess. But, through my postdoc, I realized that I no longer really wanted to be a bench scientist, and lead a research group and was really looking for anything I could do that would use my science. And, I really believed that I became a scientist because I had some authentic experience when I was young at a research lab. And that really led me into teaching and into the way I teach, which is to bring authentic research to people because I think, the questions we ask and how we solve them is some of the most fun and some of the greatest parts of science.

So my entry into teaching, whether it's teaching my students, teaching teachers, has really been through the hope that I could bring authentic research experiences to people and help them see a place for themselves in science.

Erum: What do you mean by authentic research? Is it like genuine curiosity that's what my assumption is, but what do you mean by authentic?

Natalie: Yeah. I think we are all born as scientists, right? We are all born curious. We all have a way of exploring the world. That is the way scientists explore the world, which is to try to figure out, how'd this get here? How does it work? If I break it, how do I fix it? All that's an engineer's approach, but I think we're all intrinsically curious about that. There's something about the way we teach science though, that doesn't celebrate that aspect of the endeavor. And so when I think about authentic research experiences, the ones that are really driven by curiosity and by a desire to figure something out, know an answer, solve a problem. I don't know why we would be attracting people into science and engineering, if we just tell them, you have to memorize this big fat book, and then you'll be a scientist.

Karl: And what was the authentic research experience that you had that sparked that interest personally?

Natalie: I was very fortunate, as a teenager. I was growing up in the Washington DC area. And I got to work at the National Institutes of Health when I was starting at 16 years old.

And, I remember walking into the lab was actually Marshall Nirenberg's group at the NIH and, being told you will not solve this problem this summer. And I was shocked because in high school you get a two hour lab period and you solve something. I just found that going in every day and looking at the results from the experiment that you carried out and trying to understand what was happening based on those results, was just such a satisfying way and such a new way to think about science. So if there has been a theme through the work that I've done in my career, it has been that: to try to bring that open-endedness and the curiosity-driven science into the teaching that I do and into the world.

Karl: We often talk about bio-illiteracy, which is just science illiteracy, in general. And I wonder, if you would comment on it, is that due to the way that science is taught? When most people have a high school biology, but, beyond that, such a small percentage of the population ends up becoming scientists or engineers, how related is that to the way that we end up being taught science?

Natalie: So I'll agree with that last point. I think that we do scare a lot of people away from science and engineering based on the way we teach it. But I will take some issue with two of the other points that you made, which is the idea of science illiteracy. That's a little derogatory for people. For example, my phone. I don't know how my phone works, but I use it and I use it productively. I have great photos on it because I know how to take a picture with my phone. I don't know that we need to have everybody understanding how all of the science works in order to have a constructive, thriving society that biology assists.

Perhaps an appetite for engaging with biology might be what we need a little bit more of. And then, oh, high schools, you said that most people have biology and high school. I wish I knew that data. I don't, I don't really even know how much biology is taught in the United States. High school biology, public schools are state regulated and it's really hard to get that data to know what is being taught, how much when biology is

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sometimes a ninth grade subject, sometimes it's 11th grade. There's a lot we can learn about what exactly are people learning about life science in their high schools?

And to be clear, in rural America, half of rural America, their terminal degree is a high school degree. So we are doing a huge disservice to all of America really, if we don't get high school biology right. We need a strategy for high school biology to really serve our society.

Karl: And why do you think that is, that we need to have a bio-literate society, this is like a two-part question. Don't you think that people got quickly educated on biology during the pandemic?

Natalie: They did and I think that I have heard more people use the acronyms, PPE and RNA and PCR, in these last few years. I never would've guessed that would've been the case. We are learning. I think that we don't share a common language around biology. We don't share a common appreciation about what it can do and how it could help our society thrive.

Really, that's our goal, is to have this century be the one in which biology helps our society thrive. And to do that, I think we do need a more common vocabulary around it. It should be a basic competency that we all graduate from high school with that says, you know how to read, you know how to add two numbers, and you know that DNA is the coding language for the cell.

Erum: You started BioBuilder, you've been working on different programs and you teach teachers and you teach students as well. So first, tell us about BioBuilder and then I'm also curious how young can the students be? Like at what age do students start learning or understanding about science and biology?

Natalie: Yeah. All great questions. We are really hoping to inspire this next generation to not only learn about science, but to love life science. And to do that, they need to see a place for themselves in this endeavor. Our curriculum is directed towards high school aged students. We have had some adoption in middle school. I think that, it has to look different at different stages and it will look different in different places in high school as well.

We are an intentionally malleable curriculum. We are not prescriptive. It's not do this worksheet and watch this video and give this test. We do rely on the educators that we partner with to know that the content fits into our classrooms and our labs, that they are teaching and fits the frameworks and the endpoints that they're trying to reach.

We do have a third audience, which is industry professionals, and that's been a growing effort for us as well. We've had some really wonderful engagements with individuals who are professionals in one area, finance, operations, marketing, all sorts of things. And then we bring them back into the lab. If they haven't done biology since they were ninth graders in high school and dissected a frog and that was the last of it, they have a

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chance to learn modern biology and we bring them into the lab to do that. So it's been really interesting to see where this gets deployed. and we really are trying to get it out all in every corner of this United States.

Karl: And BioBuilder teaches teachers or just, explain what does BioBuilder do?

Natalie: Yeah. We're an openly accessible curriculum that, can be found on our website and used. We partner with organizations like Carolina Biological Supply Company to have the hands-on kits that teachers can use in their classrooms. The content was co-developed with teachers so that it can meet their needs.

We have a teacher training program. It's not essential that they take it in order to use this content. We oftentimes see social media posts from teachers we've never met and don't know. But we do have a really wonderful teacher training program because teachers are incredible agents of change. They love teaching, they love learning, and to reignite that passion and the reasons they went into teaching is just a very satisfying effort for us. So we have some physical spaces in the Boston area where people can come to do this work. We have a learning lab inside Lab Central, which is just down the street from MIT, and now we have a wonderful headquarters inside of Ginkgo Bioworks in the Seaport of Boston. And we're looking to expand those opportunities to other places too.

Erum: Do you collaborate with Ginkgo Bioworks at all? or MIT?

Natalie: So much of the content came out of my teaching, as a faculty member at MIT when I was in the Department of Biological Engineering there. And I was teaching my undergrads and realized that I could teach 30 undergrads, 50 undergrads a year, but if I taught 50 teachers a year, they could teach hundreds and hundreds. So it was more shots on goal that really led to BioBuilder's start. So the content is still very MIT-derived, for sure.

And then our work with Ginkgo is ongoing. Support with a generous donation, the learning space that we have inside their headquarters building. And some of those workshops for industry professionals have been with Ginkgo professionals. More recently, we've taught more than a hundred of their staff and their executives.

Karl: Amazing. Yeah, I would say that for us, some of the most satisfying experiences that we have are having these conversations with people who, like you said, haven't had biology since ninth grade. Professionals that are mid-career that all of a sudden we open up this world to them and they're just amazed by the progress that we're making and how the entire economy is being impacted by the work that is being done in the biotech industry. One of the things I have always loved about you, Natalie, is the fact that you approach science and teaching science from a point of curiosity. I was wondering if you could just talk about that, expand upon it a little bit to share that with the people who are listening to the podcast.

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Natalie: Oh, I'd be happy to, for sure. Before I do, I'll say, any of those industry professionals that you would like to send our way for a little bit of hands-on workshops. We would love to see them and meet them. So the pandemic has had a huge influence on what we have done. It really catalyzed years and years of change within BioBuilder in a very short amount of time.

If you had asked me pre-pandemic if we could have done any work remotely, I would've said, we really are hands-on learning. We really want people to get in, know that they have capacity to work in a lab and can use those as tools to build things with biology.

And then the pandemic hit, and we really thought hard about what we could do to support the teachers and students who were in our community when they all got sent home, very rapidly, very unceremoniously. Trying to figure out how to support them and. We realized that one of our unique value adds was to really tap into the curiosity and the desire for people to work together, to design a biotechnology, to meet a need that mattered to them.

And so we developed what we called an idea accelerator. It's a three week program where people can do this online and we help them identify a topic area that they think they could address with biotechnology, and we give them a design framework for engineering a cell that might address exactly that.

And within three weeks we have students presenting two minute showcases of their ideas, using a very disciplined engineering framework for coming up with that biotechnology. And then, if they can get back to hands-on learning or wanna spend more time on it, we have some additional programming that we can lay on top of that.

But training people to think about biology as a problem solving platform is the strength of BioBuilder and we give them, as I say, the tools to think about how to do that.

Karl: Are there any examples from that idea accelerator that you could share with us that have really inspired you?

Natalie: Oh, so many. There are tons. One that is coming to mind just off the top of my head is this team in Kingsboro, Massachusetts that's been working for a couple of years now on trying to design a mosquito repellent by having a microbe make an essential oil that might be used in place of citronella candles or something like that. They are now at the place where they have actually synthesized their plasmid and they're transforming it and testing it to see the ability to produce this material.

DEFINITION: Plasmids

Erum: What are plasmids? Many people are first introduced to DNA as a genetic structure that's wrapped up tightly to form chromosomes that are in the nucleus of a cell. But DNA can function and replicate independently outside of the nucleus in the cytoplasm of a cell. Plasmids make it much easier to work with DNA and their

structure serves as a delivery vehicle or vector, which we'll hear about more, to introduce edited DNA into bacteria. And this is a fundamental step for genetic engineering and many other biotech applications.

Natalie: To take students who thought biology is something you memorize, “where's the golgi, and you know how the endoplasmic reticulum works”, right? To thinking about it as a platform for making something is really cool. We have another team in New York that's working on detecting lead in their water because their school had lead in their water. These are projects that are of great personal interest to the team that's working on them.

Interestingly, two things that I see pretty routinely with these projects that's truly inspiring for me. One is that the teams are really eager to overcome adversity, right? Like they will come up with an idea and then they'll be like, oh, that's a great idea. And then they'll do a little research and they're like, oh, somebody else did that. Or, oh, that won't work for this reason, and it doesn't turn them off. Instead they're like, okay, we'll just figure out the next step. we're gonna keep going on this. So that's part one, which I just find incredibly inspiring is the resilience that the students develop around these projects.

And the second is just the idea that

They don't question why they are learning these things. Like, how many times in school do you remember people saying, why do I have to know this? Why do I have to know how to factor in why do I have to know prime numbers? Students who are doing BioBuilder don't ask, why do I have to know this? Because they're learning it because they want to build something. Those two things are pretty consistent across the project. So the projects themselves are inspiring and fun and just as sophisticated in ways that I'm incredibly impressed by.

But I think that resilience and that, just intrinsic curiosity about the desire to learn, that intrinsic desire to learn, are the things that I love seeing.

Erum: So you have students that form teams. Are they coming from schools primarily or are they like just forming teams because they just happened to go on the internet looking for a program, they stumbled upon it, they get their neighborhood friends and create a team?

Karl: It's like starting a band. That's what I would do.

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Natalie: Yeah. No, it is a school-based program. We model it a lot on iGEM, but make it something that high school students can do during their school year, and make it much less expensive. We also provide industry mentors to help the students shepherd their projects along and help the teachers.

So teams of students of as many as 10 students at a school, it's almost like a first robotics club or a debate team or something like that. They decide that what they're working on is an engineered system to solve a challenge that matters to them. And so the BioBuilder Club runs from October to March. We're gonna have our final assembly very soon, and students from all over the country and all over the world will actually present their project.

DEFINITION: iGEM

Karl: iGEM refers to the international genetically engineered machine competition. This is a worldwide synthetic biology competition that brings together high school students, undergraduates, entrepreneurs, and community labs from around the world. You'll probably hear Erum and I say that if you want to see the future of biotechnology, you need to go to iGEM. It's an incredible event that brings together future biotechnologists.

Erum: That was really great. I asked that question because now that you have this remote program since Covid and I was curious just to see how many people can access that, not only in the US but are there people from other countries?

Natalie: Yes. So we are focused on the United States, but we are openly accessible and we have a great deal of work in other countries for sure. Our BioBuilder textbook was published by O'Reilly Media, and the chapters are downloadable on our website, but the publisher translated it into Russian and Japanese. And then we have individuals who have translated it into other languages, Mandarin and Portuguese and Spanish. And I just got a request for Arabic. I'm like, I don't read it, but sure. It would be great. Yeah, so we are eager to have this happening everywhere. At the BioBuilder Club final assembly, which will happen again in a couple of weeks, we have teams from Taiwan who are gonna be remotely presenting.

Erum: Wow. It's really great to hear that.

Karl: Yeah. I love this idea of making it globally accessible, but, and I think I've talked to you about this in the past, Natalie, where I feel like as more people understand that biology is a tool, then what we'll see is that regionally or very locally solutions to local problems will happen in the biology.

I'm thinking of a few years ago, my son, Alejandro did an internship up at MDI in Maine. And they were incubating companies that could have come from nowhere but

Maine. And I think that as more people realize that biology is that kind of tool, they'll solve problems very locally with biology that could not be solved anywhere else. So I know that you guys have done some work in East Tennessee. What's that been like?

Natalie: Yeah. East Tennessee has been one of the most surprising and delightful parts of BioBuilder and I think that we are still trying to get our heads and arms around all the good things that are happening there. We recently got a very generous grant from Schmidt Futures to try to understand that model that's happening in Tennessee. They reached out to us to try to build a local appetite for a bioeconomy.

And, the piece that we have not yet spoken about through all this is the complementary piece to formal education, which is workforce training. I am late to the game to appreciate how important it is to make sure that when we graduate our students from school, any level of school, that they have the tools that they can use to get a good job that they're proud of. And so BioBuilder, really over the last couple of years, has been beefing up our resources to do workforce training, to do more skills-based training. Make sure that the training we do is recognized by industry and by universities that will want to recruit our high school students.

That work in Tennessee is really building a regional bioeconomy in a non-traditional STEM hub. It starts with education. It starts with building in the high schools and in the region. But then it feeds into the community college and the state university there. And, they are building a biotech incubator space as well, to try to foster, as you said, the ideas that would come out of East Tennessee, that are unique to the region, that they could, deploy, and build out there. So they know how to distill things and ferment things. They are well on their way to becoming a very powerful Bioeconomy.

Karl: And East Tennessee, what's the biggest city? Is that Chattanooga?

Natalie: No, we are in that Kingsport, Greenville, tri-cities area, mostly known for, country music and, NASCAR and—

Karl: Yeah. Yeah, that's fascinating. I'm really looking forward to seeing more of those kinds of programs. There's someone who I know from Oklahoma who has been doing biotech companies in Oklahoma for decades, and I just saw him on LinkedIn and I reached out to him because I just wanna know what's going on in your part of the world. I want to know, how things are different, how they're harder, what's interesting. So I'm fascinated by this.

Natalie: It can't just be on the two coasts. It can't just be Cambridge, Massachusetts and Palo Alto, California.

Karl: Yeah. I just saw someone on Twitter who's from Michigan, also tweeting about building the bioeconomy in the Midwest. So, this stuff is all related; the Bioeconomy Act, the initiative that the Biden administration signed last October. They talked a lot about community college and workforce training, which I think is just so key because

having a job that's meaningful is so important to everybody and I don't think everybody has that opportunity. Once you start to see what the possibilities are with biology, it allows you to not just, potentially get into these interesting jobs, but also think about what you could do on your own potentially.

Natalie: Absolutely. And I will just put in a really strong hope that we can include high school graduates in that plan for the bioeconomy. We will not reach scale for these industries without including high school graduates in the bioprocessing piece of it, we turn a lot of students away from this, bioeconomy and the, and life science as a career endeavor because they believe that they have to go get a PhD in order to be a scientist. There are so many great jobs for people who could pursue this, and industry needs people who are not all PhDs. The next few years, if we are successful, we'll have a greater appreciation that high school graduation has to be part of this solution.

Erum: Yeah. What are some of those jobs that you don't require, a PhD that you can put inside the mind of our audience, that they could think about?

Natalie: I think, they're more bioprocess oriented, so things that are more, I don't wanna say maybe factory floor, if you're making a choice between, stuffing boxes with, things for Amazon to deliver or stuffing boxes for, covid vaccines to get delivered, you could be in the lab to help with, making sure that there's the right solutions going into the fermentation tanks, that the tanks are operating properly, that the packaging is happening correctly. There's a lot of GMP style jobs that's, just, good manufacturing practice style jobs.

Karl: Correct me if I'm wrong, Natalie, but I just think that a lot of things like, probably even like sequencing, DNA synthesis, all those things are gonna get to a point where they're so simple that you could do them in high school.

Natalie: Oh, I do think so. Yeah. In fact, our curriculum for workforce development includes sequence analysis because you can now send material away and get it sequenced and overnight you'll have data. The idea that we can use robots and other resources to actually get the data as I say, why are we not letting the students know that you can actually, generate a sequence and analyze it, and let them know that they have the capacity to do that.

Karl: Plus the other places, like anything that has to do with bioinformatics, that workforce is very much lacking. We could 10 times that and still not fill all the jobs.

Natalie: Yeah. Yeah. I use computer science and the growth of the computer science industry as a model, a touchstone for me a lot. We look at how computer science has influenced our lives now, and, It's profound, right? We all carry these little computers in our back pockets and, every day we have, just computation and electrical engineering like that in our lives. If bio is gonna do that, we need to make sure it's getting into the schools. the learning about it is getting into the schools. We need to make sure that people know there are good jobs. We need to make it accessible broadly. One of the

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smart things that, the computer industry did was put personal computers into libraries early on. I would love to get biotech into libraries. We've been calling them labraries, which sounds very southern, but it's funny, labraries to be able to have people just know that they can pipette and that this is what a cell looks like under a microscope and how you count cells, things that are actual skills that people would use. Just to let people know that they exist, these jobs that use these skills and that they can do them.

Erum: Yeah, that sounds like, here we have genspace, our community lab. And then, Beth, who runs the community lab here, she was mentioning that there are other community labs sprinkled throughout the US. It doesn't seem like they're highly attended, but they are attended by an array of different people. So young people, older people that wanna be re-skilled, people that are curious. Like designers that are looking at new materials.

Natalie: So I love Genspace. I've been a fan from the get-go, that sort of, gym model where you pay a little bit every month and you get the equipment and the personal training that you might need. I think it is a brilliant model. Libraries serve a slightly different role in that. When I was growing up, I went to the library every week to get new books, right? Meeting people where they are, whether that's the high school, whether it's the library, entrusted community spaces, I think will help bring biology out into the everyday language that people are using.

Erum: Yeah. And you have infrastructure like, I went to the library last weekend and of course it's filled with books, but a lot of books are e-books, there's actually a huge row of DVDs, so people are still accessing that. Not in my world, but people are. And so there is space, and I think there's been like a couple libraries I've closed down here in Brooklyn, which is a very big area, but repurposing that for a lab-rary would be a great idea.

Natalie: I love it. I love it. So maybe that'll come outta the executive order from Biden.

Erum: Yeah. I wonder, we've got to check in on that.

Karl: Yeah, it is. I think they had some very strict deadlines and we should be reaching day 90 by now, so we should start seeing some definitions and common language coming out very quickly. ,

Natalie: We'll be a part of it. All of us.

Karl: I hope so. you're talking about this idea of a lab-rary. What would that look like for you, in an ideal world?

Natalie: To me it would be, somewhere between, a museum exhibit like a science museum because science museums also exist. When I was growing up, I went to science museums far less often, right? I would go either on a class trip once a year or occasionally with my parents on a rainy day or something like that, right? But those

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exhibits always had a hands-on component and it wasn't overly technical. But it would always give you something that you could describe to somebody else later on. That would be my hope. Maybe it's a modular walk-through lab in the parking lot that comes to your library every third Thursday or something like that.

But I'd love to have it be something that people could do some hands-on work on and, really skill-oriented things, but not highly technical. Cause I do think the lingo gets in the way of people feeling like they have capacity in this.

Erum: Yeah. That's definitely a huge thing. It sounds like something's gonna happen soon. You have some legs there for these lab-raries.

Natalie: I hope so. We have so many opportunities, right? That's the thing with BioBuilder. We absolutely need people to come and bring their expertise, bring their support to BioBuilder because we do a lot with very little. And we're a small team and we're definitely punching above our weight. So as many partnerships that we can engage in is gonna help us grow.

Karl: I think what you guys have done is nothing short of phenomenal. I'm a huge fan of BioBuilder. I'm curious where's that intersection between— when people say STEM, I always can correct them and I say, don't forget it's actually STEAM. Where is it that we need to bring the arts into?

Natalie: I think the arts help you imagine what doesn't exist now, right? I think that it is tapping into not only curiosity, but imagination and so arts is vital even if we don't explicitly call it out, right? As arts, because sometimes that's off-putting. People feel diminished or pushed to the side because of it. But I think the importance of imagination in this can't be underestimated. It can't be overstated. You really need to make sure that a vision is part of it and a good vision.

I will say though, I didn't come up with this, but somebody said it shouldn't be STEM, it should be METS. Because math is really the entry point into all the science, technology and engineering. And we don't do a great job teaching math. And without that, we lose a lot of people.

Erum: Yeah. Math is definitely, it's hit or miss. I enjoyed it, and I was a scientist, a course, like I was curious, but oftentimes, at least when I was taught it was just, text on paper, numbers on paper. But I did see ads on Facebook for new math education where it's more graphical. If you look at a graph, this is actually what's happening in this sine curve when you see this thing happening. And I think that would draw a lot of people in, because it's almost gamified math, which is like a huge thing. Karl and I were just talking about this before this call was, getting people that are in the gaming industry, because that often helps with engagement and excitement, storytelling, all of it.

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Natalie: It's all there. Yep. I totally agree. Yep. And I do think there needs to be new ways to teach math that tap into that, the fun of it. and the everydayness of it, because it is all around us. We need a better sense of numeracy and what numbers actually mean. It's hard to be in a lab if you don't understand fractions. You can't make 10 to 10 dilutions. so it is all entwined.

Erum: there's like an intuition, right? There's people that know math, but they. Say that it's math, right? They know the percentages and the fractions, and they just see it visually, but they don't have the words to use to say that, oh, this is a fraction, this is the visible. they don't necessarily have that right, but they can see it and who are those people? Everyone, they're everyone. Everybody has that inside them. This is just the way that the human mind works. Yep.

Karl: Yeah. The comment I was gonna make is also potentially controversial, why are we teaching calculus in high school when really the more useful math is statistics, right? I had a really good friend who was a statistics guy, but there was this whole line of people that are like, statistics is really what matters. Calculus is a little bit more abstract. Whereas we live in this world of, like you said, Natalie, like fractions and being able to dilute things and understand percentages.

Natalie: A hundred percent, yeah. Statistics and probability. And we really saw that play out during the pandemic when people really were, not clear on what the likelihood was of X outcome or Y outcome, based on some data.

Erum: Yeah, and that's gonna be even more important now that AI's coming up. And that was the whole thing with ChatGPT. Like they'll ask a question and ChatGPT just spits out an answer, but they didn't really give you the probability or the accuracy number. And it seems like that's going to be, way more meaningful, A, if people learn it. But B, if they actually also put that upfront saying the probability that this answer is correct is 65% rather than ninety, so there's a grain of salt.

Natalie: Yeah.

Karl: So what has you excited right now in the world of biotech synthetic biology?

Natalie: I have a great curiosity about the confluence of things like automation and robotics and AI and how that's gonna play into synthetic biology. We had the foundational scientific molecular biology, PCR and sequencing. And then, we've now moved into a place where you can put additional tools on those molecular techniques. it's gonna bring some very interesting solutions to us.

DEFINITION: PCR and Sequencing

Karl: PCR, or the polymerase chain reaction, is a laboratory technique for rapidly making billions of copies of DNA. Having a lot of DNA makes it easier to study. You may have heard people talk about PCR during the COVID-19 pandemic. That's

because PCR was used to detect the presence of the COVID-19 virus. When Natalie mentioned sequencing, she's referring to DNA sequencing. That is determining the order of the nucleotides in DNA. You might remember that the DNA molecule is abbreviated as ATCG because the four chemical letters that comprise DNA are adenine, thymine, cytosine, and guanine. DNA sequencing determines what the order of those letters are in a particular DNA molecule.

Natalie: How to think about it and how to evaluate it all is still, to me, the most interesting part of it, right? You can get so much data, but unless you can actually look at it and make some sense of it. So I guess writ large, it's the sense making from all of the possibilities that synthetic biology can bring. And I'm somewhat agnostic to the application space, whether it's a new fiber or a novel additive to food or something like that. I'm just curious about the tools of biology and how they're gonna play out.

Karl: Yeah, I agree. I think that is like a really interesting space. And so what do you think things look like in 3, 10, 30 years, for BioBuilder and for biotech in general?

Natalie: In three years, we really hope to have a plan where we can replicate the work we've done in East Tennessee where we've really built interest and appetite in this to launch a bioeconomy in a non-traditional hub to just understand how that happened and what it would take to do it in other places. 10 years from now, we will have done it in other places and maybe 20, 30 years from now, we really will have BioBuilder in every high school in America, because that is our goal.

Erum: Yeah, that's a great goal. One of the things you mentioned is to help people get interested is to spark their curiosity, so that they can do some authentic research. What sparks my curiosity often times as literature, movies, books, are there any books or movies you recommend to people that are interested in biology or get them hooked in ?

Natalie: I don't know. Ginkgo likes to use Jurassic Park, which is a great book, but I will remind everyone it is a cautionary tale. I can recommend Jurassic Park, as a great point of entry with the caveat that it is a cautionary tale. And that's clearly launched so many people into this area of interest, and launched a thousand ships. I think it's pretty great. But it is a cautionary tale.

Erum: Yeah, I guess the company that's attempting to do this is, It's colossal.

Karl: Mammoth. Yeah, Colossal. Sorry.

Erum: Yeah. Yeah. Colossal is attempting to bring back the Woolly mammoth or de-extinct the woolly mammoth, and the dodo?

Natalie: Yeah. I was gonna, I was go, when you asked, I was thinking, maybe woolly would be a good one to recommend, but I actually think you can go back to the source for that, which is, I think Jurassic Park,

Karl: Was there anything, Natalie, we covered a lot, but was there anything that we didn't cover that you wanted to say?

Natalie: Some of the things I've learned more recently that keep me up at night and that I think a lot about for BioBuilder. One is the need to get high school biology right? And to have a strategy for high school biology. I feel like that is not on people's radar.

Partially because we're all PhDs, right? I loved my doctorate. Like I'm very glad I pursued that route. But we can't just have people who have doctorates, it's not gonna do it right. Figuring out how to make sure that is part of the conversation is a big deal for me. And then, how to have an appropriate financial model for this nonprofit.

BioBuilder as a nonprofit organization completely depends on philanthropic support for our operational capacity. And without philanthropic support, we're scraping by and it's hard to do everything we want to do, without enough actual financial support. And so this is a window we're in where the companies are just starting, right?

So there are not that many mature companies like Ginkgo that can pay it forward and support BioBuilder to bring the next generation along. We really need, groups with impact, philanthropy views to bridge that gap because the larger companies are gonna be here. If 20 years from now, I would be very surprised if 20 years from now the largest companies are things like Google and Meta and—it's gonna be bio. They're gonna be bio companies, but, for us to exist, BioBuilder to exist, we need to somehow bridge that gap between what is now and what is future. And that's where high-impact philanthropy will come in. So I think a lot about how to make sure that is known, and bring people in if they're supporters.

Erum: Yeah. For the first part of that, the bio education or having a standard biology curriculum in high school, are there any efforts happening on the federal level?

Natalie: It's so interesting. The federal government does not regulate public schools because it's a state running organization, yet the federal government did try to establish Next Generation Science standards that all schools should have followed. Cause you think about it, you have a fourth grader in one state, and then you have to move to another state. If you've gone to another state and there's no standards of what gets covered in each grade, the kid may never learn chemistry because they chopped around. So they did try to establish next generation science standards, and the states hated it. They pushed back and there are stories of textbooks arriving that say, next generation science standards and states sending them all back to Texas, say, get that sticker off and then ship em' on back. States are very protective about the way they teach, but there also is not enough data about what's happening. I found out only recently that in Georgia, they require four years of science and biology is their ninth grade subject. Require that, that's not true in every state. Other states require three years of science or two years of science, and I don't know that biology is anything more than an elective in some places, and I can't find that data. So just knowing what is getting taught in high schools would be a big step forward.

Erum: Come on, Department of Education. Get your stuff together.

Karl: Yeah. I mean, but it does start to get into, especially these days with all the divisiveness and politics and education. I live with an art teacher, elementary art teacher, and we live in Brooklyn and you guys are in Massachusetts, so we have very, I don't know.

I'm gonna say specific points about what education means. We're lucky to be in states that are very supportive of education and value it. And, like you said, Natalie, many people end up with just a high school degree, but it should be a very meaningful degree. You should end up with enough knowledge to feel comfortable with the world that's around you and that you will continue to be a lifelong learner. So it is disheartening to hear that, there is disdain or this pushback from states in terms of next generation science, or whatever we call it, because it means that they're missing an opportunity for defining the future.

Natalie: Yes. If we're successful people won't say just a high school education, people will say, I've got a high school education, and they will be ready and suitable for a lot of very high quality jobs.

Erum: And the re-skilling I think is really exciting. And I'm so excited that you have a program for that, for professionals to learn about biology, synthetic biology in particular, because there's so many exciting things going on. We, again, bring founders and investors and other people here that they're doing very specific things. And I feel like that could be your financial model right there, just, yeah. Getting those professionals, paying for tuition. Is that how it works?

Natalie: It could be. That is the one program that I actually personally still teach. And with my time being at such a premium, the cost of those programs has to go up. The price on that. The price has to go up.

Erum: Oh yeah! MIT education you're getting right there.

Karl: Yeah, exactly. Straight from the source.

Natalie: I know. Yeah.

Karl: This has been so great Natalie. Thank you so much for taking time out of your busy schedule to speak with us today. This has been a really fun interview. I can't wait to see you in person. Maybe we'll see you up at Ferment in a couple weeks.

Natalie: Yes, and please come by the lab if you're up here for that would be wonderful.

Karl: Yeah, absolutely.

Erum: It was great meeting you, Natalie.

Natalie: Really nice to meet you.

Erum: Thank you. Thanks for a lovely conversation. Thank you.

Transition

Karl: So Erum, what'd you think of the interview?

Erum: I was so excited to hear that she has a program for workforce development. A lot of jobs are being created because of the bioeconomy, and I think a lot of people might not identify themselves as being someone that could understand biology.

And I think there's two things here. One is that the workforce will need to have jobs that people can relate to, that when they hear of the title, like if it's, a fermentor or someone that's doing experiments, that person who might have a high school education or even a bachelor's in some other field can do it. They can be re-skilled into it, especially if they go through a program that BioBuilder provides. So I think that's really exciting. What did you take away from it? There's just so much to unpack. What did you take away?

Karl: Yeah, I mean I think the workforce development piece is key. I was actually really happy, and I think we talked about it a little bit in terms of the Biden Bioeconomy initiative. It also included financing for community colleges. Most people don't realize that there is a lot of work that happens in biotech that could be learned in high school, could also be learned in a community college. But I think the more important piece of it is just inspiring people to understand what's happening in biology, in biotechnology, in technology in general.

Inspiring with what the possibilities are, but also to not be afraid of these technologies, which is a big issue. People are afraid of what they don't know. Ellen Jorgensen mentioned that was part of her motivation for starting gen space. and you and I, Erum have talked about how the headlines are filled with AI stories and why are they not filled with biotech stories. But we do know that there is a lot of fear around biotechnology. So I think that Natalie's efforts are really important and I wanna see a lot more of that.

Erum: Yeah. I would much rather go to BioBuilder and learn key skills that I would need to work at a biotech company versus going to school for four years and then getting a job. So if BioBuilder can provide that level of opportunity for people, it's amazing. On the other hand, if I had a company where I was building a biotech company and, or not even biotech company yet, maybe I have a regular chemical company or some other company where I wanna biologize my products and I already have a team of people. How do I re-skill my team? I can't just send them all to university to get a degree. I know if I could just send them to BioBuilder with the

specific intent to make a specific product. So they could apply what they learned directly with the education they received from BioBuilder. That is a lot of value, I would say.

Karl: Yeah. Natalie mentioned this idea of an Idea Accelerator at BioBuilder, and I think that's a great tool, being able to give people the tools to think with biology. That is something that we also do at Messaging Lab. We have a bio strategy workshop that we give and help non-bio companies understand what they can do with these technologies and how they might transform them, whether it's new product creation or supply chain reinforcement or securing supply chains, or just being wildly innovative and understanding what the landscape looks like. That is something that we do at Messaging Lab and I think that, for companies that are interested in that, we're a great staff. And then, Natalie and the Idea Accelerator BioBuilder, or the training that she offers for businesses, I think make a lot of sense.

Erum: Yeah. Yeah, absolutely. It's been wonderful to work with a lot of non biotech companies and biotech companies through messaging lab. And we see a lot of ideas that are being spurred. We have a lot of ideas that we spur and maybe we'll hit up BioBuilder, who knows?

Karl: Yeah, who knows exactly. We have a little list. Yeah. And then the other thing that I think we should touch on is Natalie's idea of the lab-raries. Lab space that would be included in libraries, which I completely and totally love. However, we seem to be going through a kind of anti-library moment in certain places. So I don't know how the lab addition to libraries would play out though. I do find that to be a very inspirational idea.

Erum: What is the anti-library movement? Sounds scary.

Karl: There's certain states where libraries have always been community centers. People go there to, if they don't have internet access, they'll often go to get access to computers. Many libraries provide basic training on computer skills. Librarians tend to be people who are very knowledgeable and have access to knowledge. But there's been several states where they've been banning books that make people uncomfortable, and then they've also been cutting library budgets. So it's just an unfortunate tournament of events. And like I said, libraries are community centers and, um, we need those to bring people together.

Erum: Yeah, that's really messed up the whole banning of books. It just seems so antiquated or like a. I don't know. This is the whole, what's that show? A Handmaid's Tale. Yeah. I don't know if you ever watched that, but—

Karl: Yeah, no, I know. Well, I haven't watched the show, but I know the book, so I know the concept.

Erum: On the other side of things, I know libraries just are not being visited as frequently. People are turning more to streaming or just buying books through Amazon or getting e-books. So maybe there is something there to have the space for labs or other activities, but, in respect to BioBuilder and this episode for labs. Absolutely. It'd just be great to have more spaces. We talked about Genspace, now we have these lab-rary ideas. More spaces to do science, to do biology is a plus in my book.

Karl: Absolutely right. It's an ability to demystify things. More libraries, more public gardens that people can grow. I think these are all good things, in general.

So we've got some really exciting episodes in front of us. We will be talking to Jasmina, the founder of Arcaea, which is a company that's developing sustainable ingredients for beauty products. There's a lot of exciting things happening in that space. we're gonna be talking to Suzanne Lee, the founder of BioFabricate. Hopefully we'll get her to talk about language for describing new biomaterials. Who else do we have?

Erum: Yes, there's a lot more. We will wait till they schedule and we'll tell everyone.

Karl: Fantastic. All right, that's the pod. Thanks for listening. We appreciate you. We do have a Patreon page if you wanna support us that way. Feel free to leave comments, let us know what you like, what you dislike. We do read every comment we get. We are getting several comments per week.

Erum: Yep. Absolutely. We love to hear from you. send us a message on all of our channels. everything you need to engage with us is in the show notes.

Karl: Thank you for listening to the fastest growing biotech podcast in the universe.