Title: Cementing Change: How Ginger Dosier's Biomason is Paving a Greener Path
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GINGER: We learned one day very early on that, if you intentionally broke the material in the middle of the production process, it would just regrow itself together. And we were really excited about that.

ERUM: Hi, everyone. Erum here. Karl is in Paris at the Biofabricate conference where he's mingling with biotech companies, fashion brands, across textiles, dyes, personal care, and beauty. And you can hear more about Biofabricate from the founder, Suzanne Lee, in our interview with her, which is episode 18.

And we'll hear all about it from Karl in next week's episode. And for those of you who are listening to grow everything for the first time, or those that need a reminder, the grow everything biotech podcast is where we interview leaders who are leveraging biology to grow everything we need to sustain our lives. One of the things most people don't know is how biotechnology is being applied in the construction industry.

We have featured Prometheus materials and Ecovative episodes 23 and 24 respectively. And you can hear more about how they're working in construction, but in today's episode, Karl interviews Ginger Dosier, co-founder of Biomason, and they're making big waves in the construction and biotech industries. you'll hear how she spent a lot of time figuring out how to get bacteria to bind different kinds of sand and aggregate to make bricks.

This is important because cement is the most widely used construction substance on earth after water. When mixed with water, concrete forms cement, and that becomes a backbone in buildings, roads, dams, bridges. A lot of things, but at the same time, the cement industry is responsible for about 8 percent of planet warming carbon dioxide emissions way more than aviation.

ERUM: So we see this as a great example of biotechnology being applied in areas most people don't think about, and we hope that this is inspiring to you as you think about how biology can be used in your own industry.

So, let's hear more from Karl's interview with Ginger Dozier of Biomason.

KARL: Welcome Ginger Dosier to the Grow Everything podcast. We're super thrilled to have you. You and I, we've known each other for a while. I think we maybe met at the first Biofabricate back in 2014, but I would love for you to tell the people in our audience what you do, how you got interested in biology or biotechnology, and then tell us about Biomason.

GINGER: Yeah, well, firstly, thanks, Karl. It's great to see you again, and I'm glad that we reconnected in D.C. Recently. 2014, that does seem like a while back. Well, that is a decade now.

Well, I'm trained as an architect. That's my original background. And as an architect, one of the most important responsibilities that they have is to select materials. And as a student, we were taught about materials, the typical palette that we had, and we were starting to look into sustainability. And at the time, the only thing sustainable out there was, Interface carpet that Ray Anderson had pushed, to look at embodied energy, life cycle analysis, and really look deeply into the supply chain.

That was really inspiring to me, personally. So I remember thinking at the time, materials can do so much more. They're these inert objects, but they can do so much more that have a positive impact for the environment. I grew up in Huntsville, Alabama. My dad worked at NASA as part of the shuttle program.

And he would spend a lot of time on the weekends making improvements to the house, so he would cast a lot of concrete. As a child in the 80s, he would teach me how to use concrete, just send me off, let me play with this amazing liquid stone material. And it was really fascinating because I remember thinking at the time, like, I don't understand how this reaction is taking place.

As a way to start combining how I got interested in biology, when I was seven, it was the first time I went to the beach and it was in Gulf Shores, Alabama. I remember stopping at the very first seashell that I saw on the beach and just holding it up and just being completely in awe and wonder of how 'was this made?' And then of course, storing it in bags and taking them along with me. That really made an impact on me. As I was going through my career as an architect, I knew that I wanted to go to graduate school and graduate school for me meant going to Cranbrook Academy of Art, which is an incredible school.

Right before I left my home to go there, I had all of these possessions to make a decision. Some of them were heirlooms. Most were not. So I remember, photographing each one. I would sell them, or donate them. And I just took what was essential with me to Cranbrook.

On the drive to Michigan, I was thinking, 'it would be great if materials would just dissolve when you're done with them'. so that was one of the first projects that I worked on at Cranbrook was a dissolvable piece of furniture. What was fun about it was at Cranbrook, they have this piece in the front of the Academy, which says "Science and Art" and I just remember thinking, this is this beautiful marriage, potential, happening here. So I was thinking, well, how do you make something that you can just put outside and let it dissolve and it doesn't harm the environment.

So I ended up going over to University of Michigan and just talking to a lot of different sciences and material science in particular, and came up with a formulation on material that would dissolve once you're done with it. And then that led into some other materials that I developed about dissolvable formwork for concrete. That was another area that I had looked into that it didn't make sense that we would spend all this time and energy on making form work that you would leave in place. So I was excited about, wow, you could make something that's dissolvable and then the microbes and the soil can use it as a food source.

And that's really the first time I started to think about microorganisms, and how you can choreograph materials to be part of that system itself. And then that led me down a path of porosity and really getting deep into materials and thinking about, can you make materials that can absorb pollution?

How can you leverage that porosity and surface area to be able to make that? That led to bacteria and algae as a way to take into that porosity and do different materials, such as crystal and structures. So that was Cranbrook and the time that I spent there thinking about materials that can do more and becoming a positive influence for the environment.

KARL: **You said formwork that dissolves, but for the people who don't know what formwork is, what is formwork? I'm not sure I know what it is. I think I have a picture in my head.**

GINGER: Yeah. So, I guess one quick example would be if you go to Lowe's or Home Depot and you buy a bag of Quikrete and you want to cast something, at your house and you have a framework, if you will, like you want to make a square.

You mix up the concrete and it's a plastic material. It's very fluid. So you need a way to contain it. So that form work, if you happen to go by construction sites, you might see that a lot. They're typically made out of wood or out of steel. if they're made out of wood, they throw them away and, you see these beautiful armatures, making up a building and then the concrete that's liquid gets cast in there. And once it hardens, you don't need the form work anymore.

KARL: **And what was the step between Cranbrook and starting Biomason? What was that path?**

GINGER: So after Cranbrook, I applied to teach at NC State. So I had a few months to work as an intern in New York City, working for a friend of mine at an architecture firm.

And we had some major deadlines. So that meant a lot of sleepless nights and a lot of nights sleeping in the studio, in New York. And I had brought one of my favorite books with me. I'd read it once before. It's called Biomimicry by Janine Benyus. This lack of sleep and I was like, I am going to take a break and maybe try to take a little nap. And I read through biomimicry again, and I had this idea. It just popped in my head. Like, huh, what if you could grow cement? It was just thought that came up. I wrote it down in my sketchbook and I just kept thinking about it. I would take the train back and forth. I was living with some family in New Jersey.

So I had a lot of time to think through, what would it mean to grow cement? So, by the time I got to NC State, I found an apartment that was across the street from the 24 hour library, and I just dug straight into how biomineralization works with shells and coral and then that led into some audited courses and biomaterials.

The big thing there is that there were many different opportunities to learn about biomineralization in the natural setting from all types of aspects. And being able to pull books that were next to one another just to start to learn. And what I learned was that microorganisms play a big role in mediating the environment for crystallization to happen.

So as a professor in architecture, it's typical to not have like research or a lab, it's very much teaching and then you're also doing a lot of design work. So I didn't have a lab, but I had a second bedroom. So I decided to set up a lab in my second bedroom and I had access as a state citizen to go through and pick out different surplus equipment for pennies on the dollar and I just built out a lab in the second bedroom.

And this is well, before Breaking Bad ever aired and by the time I met Michael, my husband now I remember thinking, Oh gosh, I can't show him this lab. He's going to run away. So finally I showed him like, okay, this is what I'm up to. I'm trying to grow cement. and here's my lab and here are all these pieces of equipment.

And I had continued to audit courses as part of that. Something that was important was one of my mentors who was also a colleague. I told him about wanting to grow cement and he said, since cement is such a broad category, we can make a lot of things out of cement, maybe take it down to something more tangible that's a form that you can repeat over and over and iterate. So I chose a brick. It was small, something that fits in your hand. It's a very difficult thing to make something the same in repetition. So it was a very good way just to hone in on doing something that has a language and architecture, but then also has the ability to be iterated upon within that.

KARL: And I seem to remember, there's a very specific sand or material that is used to make bricks, and there is a significant environmental impact for making bricks. Is that true?

GINGER: Typically brick is made with clay which is aggregable land. So, if you were to build all of the bricks that were required for population growth, you would end up depleting all the arable land for agriculture. Clay is this beautiful material that's been turned over time. And it is amazing to fire it and you petrify the clay and you get this crystalline structure at the end.

Cement, on the other hand, does use sand as its component and it does typically require that the sand is rounded. So that means that it comes from a natural source and that is definitely in a state of being depleted quite rapidly.

KARL: **Wow. Amazing. When you honed in on a brick and you started your experiments to grow brick by putting sand with bacteria, describe the process and what kind of reaction you were getting from people when you said, I'm going to grow a brick?**

GINGER: I guess the way that statement comes out, it's sticky. So it's like, wait, what, explain, what do you mean? I remember talking to some of the early customers and they were thinking algae, amoebas… bacteria was somewhat of a foreign concept, but, fortunately, it is very easy to explain.

> **Well, we're surrounded by bacteria all the time, not just within our microbiome, but we like beer. We eat cheese, salami, yogurt. So there's a very quick way to explain what fermentation is, once you go through the okay, it's really similar to how coral is grown. Instead of growing in a sea environment, we're actually creating an environment that's similar to seawater so that you have the right amount of nutrients and the right amount of calcium and carbon sources for calcium carbonate or crystallization to start to form. So that became a very easy way to explain it.**

Of course we had to home in on "What do you mean grow? How does it know to stop, or how does this not make Ice-Nine?" There was a lot of very quick ways of explaining, well, you're taking aggregate and you're inoculating it with bacteria by doing that and activating the microorganisms that starts a reaction, and in the presence of calcium and carbon and nutrient, you start to get the build out of calcium carbonate and it just starts to grow around the individual bacteria and then that bacteria connects to the other bacteria and then those biofilms connect to the aggregate particles.So you're essentially gluing and stitching everything together and making it more dense. It's not growing outward like bread, it's essentially becoming more dense in that process, so that became very quick to explain, and then when it came to pilot production, it was very easy to also walk through, "This is the typical concrete precast construction equipment. It's the same. Instead of adding Portland Smith, we're adding bacteria." And then the rest of the process continues from there.

KARL: **Could you define aggregate? What does that mean?**

GINGER: Yeah, so, concrete is made up of cement, sand and aggregate. And aggregate here, it's like gravel. It's basically a way to determine the size of small gravel pieces. You need that blend. So that you have big particles mixed with smaller particles so that they're filling in spaces and you don't need as much cement to form and bridge the connection. So the game is how can you use as little cement as possible to get a consolidation?

KARL: **Got it. And I often in presentations that I give about biostrategy or biotech. I have a very nice picture from Biomason that shows, I want to say it looks like a greenhouse for anybody, if they can picture that.**

But the reason I say it looks like a greenhouse is because you've got the bricks on multiple shelves or layers, and then you've got water being poured on them or sprayed on them, as you would see, like in a hydroponic setup in a greenhouse. When I tell people, this is what it looks like to grow brick, they go, "What do you mean? Is that still the process as you've scaled up? Does it still look that way?"

GINGER: It's similar to that. I think maybe what's missing too is that front end approach of seeing the sand and the aggregate mixed together, the bacteria getting added, and then it goes through this compression machine so that it's, vibratory compaction is what it's called, and it stamps out different sizes of precast. You can go very big. You can go into bricks. You can go into tiles. Doesn't really matter. And then it's almost like making a sandcastle. So you're just forming and then releasing so that you don't have the form work and then it just keeps coming through and pushing on to the next step of production. And then what you're describing is that curing step. So you're right, it is a liquid system. It does require the ability to have a liquid system so that the solid state fermentation can take place. And when I say solid state fermentation, I just mean that, it's actually living while it's growing.

So you're inoculating it with a small seed culture of bacteria. And then, it just continues to multiply once it's in that shape and then it's able to use the nutrient, the calcium and the carbon sources as part of that. Once you get to the densification, that's required, then the process is done.

KARL: **I'm super curious from a scale perspective, how much brick is produced today and how much brick does Biomason produce?**

GINGER: So brick is typically viewed as a clay based material versus a concrete or cement based material. We really only used brick just to prove out some of the early pieces. Now concrete and precast. So, the concrete market is broken into precast and ready mix and 85 percent of the concrete market is ready mix. And that's what you would see when you would see a concrete truck going through New York, hopefully pretty quickly so that it can get to the site where it needs to deposit.

Then the precast market is quite large. It includes anything from pavers to panels to tilt up, anything that essentially uses a formwork or a vibratory compaction as part of that. So, what's been exciting about watching Biomason grow over the past 11 years is once we started working with the Department of Defense, we were able to scale up to doing large walls with them, like preventment walls.

So, thinking about being in a remote location, you don't have the payload ability to bring in all the Portland Cement, all the aggregate and all the sand. But can you use what's there? Like the sand that's already there and consolidate that and make these very large walls. And so that was really exciting to work on that.

Like I said, the precast market is quite large. Right now Biomason has completed 2 pilot plants and then there's a production facility in Denmark and that's very exciting. And that's essentially, the demonstration of the business model, which is to put this technology into as many concrete manufacturers' facilities as possible in precast as the company has a product development roadmap to get into ready mix.

KARL: **And what's been the reaction from the... Do we call it the concrete industry or the cement industry?**

GINGER: They're two different things, but you can also interchange them. I mean, the concrete industry is dependent upon the cement industry. And I guess you could say the cement industry is dependent on the concrete industry. That's what's exciting for the precast companies, is the ability to make their cement on site and not be dependent. For the cement industry, they also know that they need to make some changes and there's a lot of great technologies that have come out but they don't solve the root cause problem.

I think that being able to still leverage what supply chains they do have, like limestone, and being able to use that is important to these companies. But there are major changes that are taking place right now within the industry for doing things like adding solar calcination, starting to inject CO_2 into concrete.

Anything that we can do to start to get that 8 percent down. While new technologies and novel cements, which are not the same as Portland cement come out so that they can start to replace and work with the industry to enable that to happen. Not being this additional third party out there, but being able to usher in with the existing industry.

So, the concrete producers have precast. Think about in cases like countries like Denmark, there's only one Portland cement producer. So they're beholden to this one producer. And that means that prices can go up, delivery can become a bit challenging, but essentially to be able to control your margins, it's much better to be able to control your cement.

KARL: **We had Lauren Burnett of Prometheus materials. And one of the things that really struck me about the conversation with him was around the performance characteristics, but what about the performance characteristics of the Biomason end product compared to your regular cement or regular precast?**

GINGER: A couple of examples, some going way back. So, once, back in the second bedroom lab, once I was able to get some success, I wanted so badly to see inside of the material.

So, of course, putting it through rigorous testing, but then also putting it under scanning electron microscopy to just see what's going on. And what I noticed was that the sand that I was using at the time was actually coming from the UAE. The UAE is the largest importer of sand in the world.

It's because the sand is alluvial. It's very fine. So it's very difficult to use for concrete. So you need different grades, if you will, of sand and aggregate for concrete so that unfortunately must be mined somewhere else and then brought in typically. Structurally, you're like, okay, well, this is a very small amount of cement versus the relationship of the amount of aggregate or sand that's used in that yet we're able to get strengths out the gate. We hit strengths that were higher than a concrete block, which is about 1800 PSI.

So we were hitting strengths above 1800 PSI a long time ago, and then trying to figure out like, yeah, it was great. It was like, well, how did that happen? And why, what does that mean? Because concrete, depending on the application, it also needs to be tailored for performance, so compression. So, high performance concrete is, typically around 10, 000 PSI.

So we were able to prove that later in the years too, to be able to get, way, way up in terms of the performance. So we started to investigate like, okay, well, , how does this even work? And it looks very different under SEM when you compare it to Portland cement, which is more of a gel or a plastic inside. So you're essentially packing in a bunch of crystallization versus this growth of crystallization, that's just stitching the structural lattice type of way. So that gave us some hints like, huh, this is different.

> **And then when we started to get into testing for freeze thaw, we noticed that when you push material to failure, which you need to do to understand how many cycles, for example, it can handle getting, really hot, really cold, really hot, really cold. What we found was that we were losing mass. So like a few grains of sand or aggregate would fall off versus like cracks forming.**
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> **That was interesting to us. So we're like, well, how is this possible? And does that mean that this would be better in earthquake locations? What we learned later was that bricks or concrete falling off of buildings is actually one of**

> **the biggest causes of human harm. And we learned that the way that those fluid paths and then the way that the crystals were forming that structural lattice actually allowed for water to not become trapped within the core of the material itself.**

So that was really exciting. Another performance that came up was we learned one day very early on that, if you intentionally broke the material in the middle of the production process, it would just regrow itself together. And we were really excited about that. And then probably around the time you and I met that was around the time that we started talking to DARPA. That was an exciting project to start thinking about, well, could you take this technology and make it live in perpetuity and have self repair as part of the performance.

And so then that led us down a path of developing applications outside of construction that included dust control. Runways for the Air Force Research Lab, helicopter landing pads, and then the marine cement itself, and then later on, the larger precast walls. I know that there were ballistics tests that were run, launch tests the material behaved in a very different way than Portland cement.

So there's, a treasure trove of knowledge to continue forward. Portland cement's been around for 200 years. So being able to dig into biocement and starting to look at what are all the different unusual performance features that you have that's different than a Portland based cement.

So, for us in the beginning, it was, let's meet the standard. Let's exceed the standard and then let's see what's unusual and look to see what's possible in terms of applications that Portland cement just can't do.

KARL: I think that's amazing because looking at the beauty space, I recently read a paper that talked about, in beauty, there's been 100, let's say 150 years of formulation with chemistry, but now you have all these biological materials that are being developed. And so it's going to completely change the way that products are formulated. And so hearing that the performance characteristics of Biomason's product, of the Prometheus product being different and still not really being completely understood, is exciting because it just shows that biology is going to open up this completely different path with new materials that we are just not aware of.

I do have one question. You said that The PSI for concrete is 10,000 PSI. That's what people aim for. Do you happen to know what it is for seashell or coral reefs?

GINGER: I don't. My suspicion would be that depending on the type of coral, depending on the type of shell, you would get different performance.

I do know that with shells, especially, ones that have a material called nacre inside are very interesting because they have the ability to have compression and tension together as a layered approach. And the 10, 000 PSI is the upward end, that is a really high PSI for concrete to achieve. But that is a great question to see where those natural cements are peaking out in terms of compression.

KARL: **And where do you need that kind of performance, because to build a skyscraper, you probably don't need that. You need, I would imagine, some flexibility built into it. I'm not an architect. I know enough to get into trouble just because I see all the buildings around me.**

And there's, I live in a neighborhood over from Gowanus Canal where they're putting in 8, 000 units. So there's a lot of construction, a lot of cement trucks. But then Brooklyn is now getting a supertall. And again, the evolution of these things is amazing to me. And I just learned that the supertalls include several floors that wind can blow through so that the buildings don't flex as much. And I was like, who, what engineer figured that out. It's so brilliant?

GINGER: That is brilliant. That reminds me of the dampening balls that you have on the very tops of skyscrapers. So it's like a counterbalance to the wind. It's something very interesting to add to the design program when you're designing a skyscraper. So yeah, you want those buildings to move.

KARL: **Yeah, and I just wonder how that changes when you're using materials like yours. and then there's also been this trend of using engineered wood. We're seeing the first skyscrapers go in. I think the tallest one is in Norway, maybe 14 stories.**

We just had an engineered wood building go in here in Park Slope in Brooklyn. It's a five story apartment building. And I know that they're building something in the Midwest, either in Chicago or Minneapolis. It's also going to be engineered wood, completely designed, completely built before they assemble it. Definitely more than 10, maybe even pushing 20 stories.

GINGER: It's an exciting time for materials right now.

KARL: **I agree. Yeah. So can you give us a little bit of a description in terms of the growth and evolution of Biomason in your role? And you guys had raised a series C in 2022, how has that changed things?**

GINGER: Yeah so Biomason turns 12 this year and just looking back, at last decade I'm very proud of the team's accomplishments. It takes a lot of disciplines. So, at one time, I think we had around 56 different disciplines represented. And it was so exciting just to see the different languages that would come up, all the acronyms, of course, the internal teams need to develop to be able to communicate and yeah, pioneering a new industry. It's not like you could just order pieces of equipment or tools of automation to be able to work with Biosummit. We had to do a lot of that ourselves.

In fact, When Michael, he went to London for graduate school. And I think at that point I just took over the whole house and made it into a lab. And when he got back, he said, “Oh my gosh, like we need to automate this, you're having to feed on this frequency that precludes us from being able to go downtown for dinner. So I'm gonna make some equipment, make some machines.” That was really exciting to start to figure out, okay, well, what data do you need to collect? And collect data like NASA, all the different readings of, just trying to learn and understand.

So I'm very proud of that because it taught us a lot. It gave us as a team, just a very close look at the material itself as well as, getting into the DOD funding. Now what's exciting is the commercial plant in Denmark. So being able to see the technology transfer from the US all the way to Denmark is very exciting.

> **My vision has always been to see Biomason to become just this large commercial engine that's delivering biology to the cement and construction industry. How do you put this into hundreds of plants? We need to be able to make these impacts. It takes the volume of something like the cement industry to be able to have these large, large volumes of biology open up new supply chains and open up new possibilities within materials.**

So yeah, we closed on our Series C funding in 2022 and the company has become much more commercial, really exciting, starting to get further into Denmark, starting to get further into what some of the next big plants are.

Yeah, I have a great view. I get to sit on the board. I get to witness and I get to influence the decisions and start to see this technology really get out into the world and make some impact. And then, meanwhile, really looking like, what are the next big questions? What are the next things that are going to hold up technologies?

Like, do we have the fermentation capacity? Do we have regulatory? Do we have government support? Do we have the right influence? There's the quote about the tipping point, meaning 15 to 20 percent of the market. How close are we? How close are we as an industry, Synbio, bioeconomy, et cetera.

How close are we together collectively there to really push? Because the infrastructure that we need to be successful has to be built very soon for us to look at where we are going to be 5 years from now, 10 years from now, 30 years from now. So, I spent 11 years of intense myopia on cement and biocement.

And it was an incredible journey. I've spent 42 percent of my life thinking about biocement. It's been very exciting to think through how do you have a question and then look at all the different elements of growth that can come out of that. But what are some of the other big questions that are coming up?

And, what does it mean for us to acknowledge that we are in the Anthropocene and that we are at a time and a place where just like putting out the covid vaccine in 8 months, we can actually collectively point towards solving some of these big, big challenges. I'm excited that the company is commercial and that it has the attention.

And then I can also look at that bigger picture and think about things like, for Spotify, where would Spotify be if the iPhone wasn't developed. Like what are these catalysts that are required for companies like Biomason, for companies that are working with biology and the bioeconomy.

KARL: I think when I first met you and heard about what you were doing, I pictured being able to containerize the production facilities and just ship them anywhere in the world. And it sounds like that was part of the work that you did to the DOD, but I think you're a perfect example of what distributed biomanufacturing looks like. And then the question really becomes how quickly can you deploy that globally? In a way that you say, you compared it to the covid vaccine being developed in eight months. How do we distribute the manufacturing of biocement globally as quickly as possible to all the places that are intense cement users.

GINGER: That's right. Yeah. And for the industry in general, we need to get out of the tank and away from corn. We can't have all of our fermentation in these stainless steel tanks and we can't continue to develop biology and technology around corn and glucose. There are so many diverse and, as you mentioned, the distributed looking at different locations and locales ability to leverage feedstocks and streams that in supply chains that we haven't thought about, we've only discovered 1 1000th of 1 percent of bacteria on the planet.

And if you think about how many potential challenges and current challenges that biology can solve. This is an incredible library. So the future for me of biology is really about providing access to that. And, the research that it takes to really understand the mechanisms and then what problems those can solve so that we can basically push these pieces through and depend upon that infrastructure that we build for being able to, put massive volumes biology out into the world.

KARL: Yeah, I'm super fascinated by this. As I was thinking about my plan for 2024, distributed biomanufacturing was at the top of the list. One of my plans is to dig into this a lot. And then also looking for global examples of what people are doing, because I think we say it here a lot on Grow Everything that, biology is global, microbes are everywhere.

So some of the discoveries and some of the innovations will come from places that we don't expect them to. But then, in addition to that, like you say, there's so much microbial diversity, being able to take a facility that you guys create, say in North

Carolina or, in Brazil and then transplant that to another location and tweak it so that the bacteria are local using local feedstock, I find to be very, very exciting.

GINGER: I completely agree, and I think it's already part of the supply chain, at least for concrete anyway, because sand and aggregate are so expensive and heavy to ship around the world. So you're already having to depend upon that local supply chain and being able to find, feed stocks. I know in the UAE I got really excited about using the sand that was there. But then also the date waste, when you take the dates and you remove the pit, you actually have a lot of remaining fruit and meat that's left on the pits. So being able to leverage, waste resources. And then, of course, getting even deeper into what are some of the different waste treasure troves that we haven't really thought about that are either byproducts of our consumption or something that we just haven't thought about, or maybe it's just pollution itself.

KARL: Yeah. That's crazy. I remember when you had told that UAE story, the way I remember it is probably different from the way you told it, but what I remember is you saying something like, "They're surrounded by sand and yet they're the biggest sand importers in the world because they don't have the right kind of sand for making concrete." And that just seems so crazy and then you think about that on a global scale. How many other places in the world are faced with that same kind of challenge?

I think about The Line or the NEOM project that's being built in Saudi Arabia, this multiple-mile I think it's 100 miles long and I'm looking at it and I'm going, where are they bringing all the steel? Where's all the concrete coming from? Are they building any of that stuff on site? Are they growing any of it? To me, if they're not doing that, they're missing a huge opportunity to demonstrate that's what's possible.

GINGER: That's right. John Cumbers, meeting him in 2010, he invited Michael and I to come out to NASA Ames. And then we ended up being visiting faculty there for a summer, really looking at how you can use biocement for Martian habitats or lunar habitats? And it's great. You have very small payloads. You bring the organism and you try to use everything that you can find, or you depend on these different supply chains.

And I think that's a way of thinking too, even in a Department of Defense, for example, it's just too cost prohibitive or you don't have the time. And in places like you're mentioning in Saudi Arabia, it's very similar to bringing in everything and from a very far away place, what can you use that's already there and just leveraging the ability to have low payloads within that.

KARL: You would think that we would learn our lessons from something like COVID and seeing how delicate and broken supply chains are. But we just went back to business as usual. There are enough of us talking about supply chain fragility, but the number of people that are trying to make an impact on that, I think, is still very small. And I think people don't realize how complicated they are. And maybe if we move into a multipolar world that will facilitate and accelerate this regionalization or

localization that will force people to look for the resources locally and think about them differently and hopefully use biology as a resource that makes these things possible.

GINGER: That's right. Yeah. I love that world. It seems like a world that you're describing affords so much innovation and opportunity and imagination as part of that, I know that was something that 3D printing as an industry wanted to be able to do, right. Having on demand, but in the sense of this location “Oops, I forgot to bring my wrench, to space. Oh, wait, I can just 3D print it from here.” So it is similar to that mindset here on earth. Being able to leverage what we have. I think today that is us ordering from Amazon prime and delivery tomorrow, the on demand type.

It is difficult. You don't want to see the supply chain. I think that you're right, business went back to usual, but maybe something that didn't click was the entire history. I know a long time ago, there was this video that came out of a can of Coca Cola and how many different countries it travels to and how long it takes.

And you have to go to this country to get this coating and then this country to get that coating. And then it takes a few seconds to drink it. So, being able to showcase examples. We don't have the transparency that we need. And maybe it's time for something like Henry Heinz pushed for when he was developing ketchup and put it in a clear bottle because he wanted it to be transparent and then you had a lot of competition come out and that's actually what fueled him to go advocate for the Food and Drug Administration. So, it seems like we're at a place right now where there's just not enough knowledge about where our products come from that we pick up at the supermarket or that we have delivered to our home. We don't see that entire story. And maybe in some cases we don't want to, but it's just not in our face. We're not confronted with it enough.

KARL: And I think because we're not aware of it and because things are subsidized in the way that they are, we're not really aware of the true costs of things. I just think of like, we're both wearing black shirts, and you look like you're, I think I've seen you wear this. It looks like a very expensive black shirt. I'm wearing a Patagonia long sleeve T-shirt that's very expensive. I know it came from somewhere in Southeast Asia. Black is supposed to be the worst thing to dye. And yet here we are wearing it.

But did we really pay the cost for what these products are, meaning, if we took into consideration the amount of fuel, the human labor costs? I know when you go and you buy fast fashion you’re definitely not paying the human cost, or when you're buying some fruit that comes from Chile in New York City and the dead of winter, you're not seeing that entire cost built into it.

But the other thing I think about too is, even though there can be this, regionalization or localization, biology is still super data intensive. And so being able to share that information broadly so that I can say, “look, here's the microorganism we're using in North Carolina that works really well for us. We've got this waste stream.” And then

I'm now in Panama. And I could say, "well, we've got this other waste stream, I can't really find the right bacteria, can you help me figure out what I need to tweak so that I can make this happen?" I think that's the kind of sharing that we also need to see as we distribute biology globally and enable more people to use it that way.

GINGER: I love that, girl. I think that really hits home on what I guess we've seen happening with subjects or education industries becoming siloed.

We are also siloed as corporations. We are also siloed as academics. We're siloed of data. So this is probably one of those places for AI to help stitch together. It's about that access. You only know what you know, you don't know you don't know. So being able to have some type of linkage and network within that.

I find that completely fascinating. And it's something that seems to be discussed a lot right now too. And as a way to be fast, and I think the word urgent is a bit overused, I think just being able to stop wasting time. What is actually going to prevent the 21st century from becoming the century of biology, would that be part of it? It's just, oh, well, we're just not open about the access or we haven't found a way to translate the information in a much more expedient way so that if you do have a known problem that you do have a known solution, how can you expedite that?

KARL: **Absolutely. So I want to be very mindful of time.I've got a couple of Quick questions, unless there was anything else that you wanted to bring up that we didn't get to talk about. There's so much I want to have you back on because this is so fascinating and I feel like we can continue this conversation for at least another hour.**

GINGER: Yeah, I think that we covered a lot. It's a great time to be in biotech and it's a great time to be in cement and concrete. It's a great time to be humans right now because we have a lot of problems and a lot of amazing solutions that will come from that. That's at least the hope that we maintain an environment and perspective on, putting our great minds together. We put someone on the moon in a very fast amount of time before we put wheels on luggage.

KARL: **Right! And what do you see as being the future of biotech in the next three, 10 or 30 years? I know it depends on this urgency, but what's your point of view?**

GINGER: I think it's the mindset around feedstocks and fermentation. Get out of the tanks, get away from corn. They are solutions for some things. They're not the solution for everything. I think that's a big one.

Being able to advocate and have the influence that's required for government support. There are 20 strategies now globally that have been adopted for the bioeconomy. So that's exciting to start to see more conversation. I think that the next step might be translating in between. Like, what do we mean? How have we defined it? How has this other country defined it? I think those will be important as well as, looking at the transparency in the market like you said, the real cost of something and being able to educate, have a piece of the education because we're humans. We love stories. We love to know things. So being able to know, if we were both wearing a black dye, that was biologically made. That's a story. It's something that you can understand. And I think in a way, it speaks a completely different language to us. So, that's really where I am.And just, pushing for this diffusion of innovation theory so that we get to the tipping point that we need.

KARL: **And is there any biotech product company that you particularly admire?**

GINGER: Oh, there's so many, there's so many, and it's been exciting to you just to take a look at the landscape, but it's just changing so much.

I remember the last event was Synbio Beta. It's just like mind blowing, like how many companies are coming out. And then every iGEM you go to, it's just, completely fascinating what's going on. So there are a few. I think that Endolith, Liz Dennett, I'm really excited about what they're doing with biomining. I think it's another one of those big industries, these big challenges, and it also means big volumes and a lot of research and diversification. It's not just, "Oh, look, there's this one organism that can do this." No, there's a suite of them. Ecovative, I've been a huge fan of Eben's for a long time.

I think that it's one of those cases to look at how he has, definitely stuck with mycelium and then looking at all the different applications and continue to be a very strong thought leader within that. And it's a fascinating company to look at how many different ways you can use mycelium.

In terms of, again, advocacy being loud out there, I know with Parley for the Oceans, they're not necessarily producing like a bio product, but because they're using a waste product, they're also enabling ecosystems and biology to continue to persist. And I think that they do that in a way that has that story piece, but then also it's driving our herd mentality as humans to be able to align towards that.

So I think companies like that, and again, there's just so, so many and so many new ones that are coming out. All of them. I think there's admiration for every single one of the companies that are tackling the bioeconomy because it's new. It's a new industry and it's not like you can just go to a bookstore and pick out a book and figure out how to do it. There's a lot of rolling up your sleeves and coming up with new strategies, new business models, new economies as part of that.

KARL: **Yeah. As we came into this interview Goldman Sachs had announced that they raised a 650 million fund to focus on biotech. And I think I said on Twitter, but how much of that is going to non healthcare biotech? And it turns out, zero. So it just shows that the financial institutions still don't really get it. And that is a story that I hear over and over again from the finance people that I know here in New York. It's a story that they still need to hear more of and hear more successes about. So I think that we have a lot of work in front of us.**

What you're mentioning is our responsibility in our role to also put that story out there to educate that biotech does not just mean pharma, that you can grow concrete, for example, it's not squishy, there's a very different type of application.

GINGER: Like you said, I think that there's a lot to do. and then, thank you. I know every time we talk, we like to talk about books and different things that we're reading. so, for the audience out there, I know I've been influenced by so many books lately and Sapiens, for example, Yuval Harari, I think is one of those books that just changes the way that you think. Super Fly, by Jonathan Balcombe. I took a trip this summer in Morocco and I swatted at a fly. And as sensitive as I am to the environment, I'm like swatting the fly and one of my friends goes, "You should read Super Fly. You'll think about flies completely, completely differently." That's a great one.

Sum by David Eagleman is just a really fun, creative read on tales of the afterlife. [On Netflix] Unknown: Cosmic Time Machine. It's a story about the James Webb telescope that is just fascinating to watch, how amazing we as humans are when we put our minds together on solving something so massive and unknown, hurling up this very, very expensive telescope into space so that we can have eyes out there to see the world around us.

And then two films, one is Leave the World Behind which I think for all of us has been fun to watch, but then if you follow it right after with watching Super Pumped the story of Uber.

KARL: **I don't know what Super Pumped is. So I'll have to check it out. And I have been listening to, based on your recommendation, Sum. It's a perfect book to listen to on the subway because the chapters are short enough that you can get one or two in and then as I'm walking to the office, I'm like, Oh, that was an interesting idea in terms of like, the afterlife. So I really appreciate that recommendation and I'll have to check out Super Pumped.**

GINGER: Yeah, it's the story of Uber just as a quick description.

KARL: **Interesting. Okay. All right. Well, thank you so much, Ginger. I really appreciate having you on.**

[Outro]

ERUM: What a great episode. I love the fact that Ginger's background is not in biotech. she's an architect, and how cool is it that her father worked at NASA on concrete, that she works on concrete and was a visiting faculty at NASA?

I mean, I bet her parents are so, so proud of her. And one of the things that they brought up that we've talked about often on this podcast is the idea of decentralized manufacturing. Something that Karl and I have been talking about. I think it's on the tip of everyone's tongue when it comes to using biology to manufacture products,

especially when we have constrained supply chains and how supply chains cost a lot of money to manage and of course, contribute to climate change.

There's a lot of value to be had not only, I mean, yeah, we all want to make sure that we have practices that are sustainable, but we also, as businesses, want to make money and decentralized manufacturing can be a key to unlock that.

Another thing that I really appreciated in this episode was a term that Ginger used, discussing how you can create a suite of microorganisms to solve a problem or make an ingredient and this really had to be thinking about a microbial assembly line. Now, stick with me for a second, having a microbe make one product because it's good at making that one product. And when I say product, I mean a chemical or an ingredient, and it's good at making that one ingredient. Then that ingredient is then shared with another microbe that can make it something else. I am not doing biological manufacturing, I am speaking to a lot of leaders who are doing that, but the whole idea of a suite of microorganisms that are working with each other, yes, it kind of sounds like a microbiome, but I am definitely thinking of it a little bit more differently microbiomes.

I'm thinking more cohabitating. And I don't know much about them on how they work together? Often I think that they work separately, but okay, maybe digressing from the idea by just that term, a suite of microorganisms that companies can use. Oftentimes, when we speak with biotech leaders or companies, they are leveraging one microorganism.

We have interviewed Stephanie of Persephone Biosciences. And Aaron Schacht of BiomEdit, who are working on the microbiome, so those would be great episodes to listen to, to kind of get that idea of microbiomes. But it's just an interesting thing to consider. How can we create a microbial ecosystem to make the products that we need to sustain our lives?

So that's the pod. If you have questions about what was discussed on today's episode or suggestions on who we should interview or just want to share some deep thoughts with our community, please feel free to give us a call or text us. We do have a number, the Grow Everything hotline. You can find that in the show notes. I recommend that you just add it to your contacts and send us all your biotech whimsy that comes across your mind.

Please follow us on Instagram, Karl, myself on LinkedIn. We're always talking about what's going on in the biotech industry. We're always going to events. So if you want to be involved, please do. Really appreciate you listening. Stay tuned for the next episode and have a great day.

