Genome Insider S4 Episode 5: Experimenting with EcoFABs for Student Labs - Jill Bouchard & Ying Wang

Menaka: Today we're headed back to school. Specifically, to a class called BIO 21 – an undergrad biology lab.

Jill Bouchard: Good morning everybody,

Menaka: We've started at 7:50 am.

Jill Bouchard: Let's give everyone just a couple more minutes before we go ahead and get started, but there's a question on the slide..

Menaka: Jill Bouchard teaches this course.

Jill Bouchard: We are at Los Medanos College in Brentwood at the new campus.

Menaka: That's Brentwood, California, in the Bay Area, about an hour away from Berkeley. And don't worry. We're not in for a four hour lecture. Jill is teaching a lab class.

Jill Bouchard: I want to get you up, and working on the ecology research projects,

Menaka: Around the room, students sit at high black tables with their lab groups. A quick roll of who I heard from, before we get to what they're up to.

Joseph Esquivel: My name is Joseph Esquivel, how are you?

Kylie Johnson: Kylie Johnson.

Sergio Gonzalez: Sergio Gonzalez.

Gabriela Canel: Gabby Canel

Lawrence Cabansang: Lawrence Cabansang

Marlena Madrigal: Marlena Madrigal

Lauryn Painter: Lauryn Painter

Lorenzo Navales: Lorenzo Navales is my name.

Menaka: Back to our lab activity. Students are a few weeks into an experiment, where they're all growing their own batch of small plants.

Jill Bouchard: So I think you all know the drill at this point, so you can go back and carefully collect your EcoFABs…

Peter Andeer led the design of the EcoFAB 2.0 device. This is the device students used in Jill Bouchard's BIO 21 course at Los Medanos College. (Thor Swift / Berkeley Lab)

Menaka: What is an EcoFAB, you might wonder? It's a small plastic growth chamber where plants grow without soil. A little like an ant farm, for plants. Berkeley Lab researchers developed this technology. And we'll spend lots more time describing them later. For now, the task at hand is keeping seedlings stocked with water and food. Students are giving their plants both with a liquid, called a growth medium.

Joseph Esquivel: So we're just adding more media so that those plants can keep on getting those nutrients so they can continue to grow. So we're just absorbing everything, see if there's any changes from last week.

Menaka: Each group is running its own experiments with the same species. It's a plant that researchers study at the JGI and around the world. A tiny grass with a big long name.

Lorenzo Navales: Yeah, I think everyone you'll see here is all growing Brachypodium, but they're all doing like sort of different variations on how it grows,

Menaka: Because each group is testing their own research question.

Tina Basu: We are trying to figure out the soil diversity and how it affects the growth of Brachypodium.

Marlena Madrigal: So, so far we look like the peat soil has the best growth.

Gabriela Canel: We're trying to see if maybe the different levels of nitrogen will affect the growth.

Lauryn Painter: We're trying to see if microbes — introducing them will cause the plant to thrive even without phosphorus.

Menaka: And by testing a research question in these little growth chambers, these students have something in common with researchers around the world, at national labs and universities all over. They're all running their experiments inside the exact same device, the EcoFAB.

Because EcoFABs were not made strictly for classrooms. Originally, they're for lab-scale experiments. But their strengths transfer nicely to a course. So Jill Bouchard's BIO 21 students are piloting lab activities with EcoFABs, with help from Trent Northen's lab and the JGI. This episode, we'll spend some time with those students to hear how these little plastic boxes are making research possible across the science ecosystem.

Menaka: This is Genome Insider from the US Department of Energy Joint Genome Institute. Where researchers discover the expertise encoded in our environment — in the genomes of plants, fungi, bacteria, archaea, and environmental viruses — to power a more sustainable future. I'm Menaka Wilhelm. Before we get back to EcoFABs and BIO 21, I want to talk about why you'd want a petri dish for plants.

It comes down to our quest to manage climate change. And that means looking at a big, giant process — the global carbon cycle. In part of that cycle, humans, and other life forms, but mostly humans — we take organic molecules, and turn them into gasses like carbon dioxide and methane. In the atmosphere, those gasses warm our planet.

But plants reverse that process. They take carbon from the air, then tuck it away for storage. That happens in their structure, but more importantly — it happens in the soil. Underground, compounds that were once atmospheric gasses become a wide array of different molecules. And microbes play a giant role there. They're the ones who transform plant organics into molecules that can stay in soil.

And so this is a whole ecosystem process that we want to understand much better – basically, when do organic molecules stay in the soil, or leave as atmospheric gasses, and why?

But if you think about field experiments where you study plants, and the microbes hanging out around their roots outside, it's hard to get accurate measurements of microbes, and organic molecules. Plus, your control over conditions isn't super precise. And that makes it very, very hard to repeat an experiment.

So researchers in Trent Northen's group at Berkeley Lab set out to study this more closely. They wanted to run isolated, observable, reproducible experiments on model plants and their microbes. Because if they can figure out how plants and microbes affect the organic molecules in their environment, it could lead to ways of slowing down climate change.

That's where they came up with the EcoFAB. It's a way of studying specific plant and microbe species, similar to the way that microbiologists use plastic petri dishes to study colonies of bacteria. Then, they improved that device to create — the EcoFAB 2.0. A researcher named Peter Andeer led that design, and EcoFAB 2.0 is what landed at Los Medanos lab courses. With that, we're ready to roll back to BIO 21. The students who have worked with them can describe these EcoFABs

Joseph Esquivel: Kind of picture, like a plastic box with the little strip where you could put a little seed inside there and it grows. It's really cool. You're able to see like the roots and stuff like that.

Marlena Madrigal: It's a clear square box, and the media goes in the middle in a circle, the

sprouts grow.

Sergio Gonzalez: Just picture something like squared and like a Lego. Pretty much. That's how I see it.

Menaka: If you're dying for an image – check our transcript on our website, we'll post one there! These EcoFABs are roughly the size of a small takeout box – think of the kind of box you'd use to take home a slice of pie. The ceiling of this little box stands a few inches high, for a plant's shoots to grow upward.

And importantly, students are using these devices without soil. In each EcoFAB, between two layers of plastic, there's a flat, circular chamber. The chamber is clear, so it's possible to watch the roots grow. Like the plant is living in its own little ant farm.

And that's one of the big advantages to doing experiments in these EcoFABs. It's possible to pop a plant in, control its microbiome minutely, and then measure chemical outputs, and image the plants roots.

These are sterile, they're self-contained, and they're standardized. They're designed so that if a researcher in Indiana runs an experiment, someone in India can repeat the same exact thing, in their own EcoFAB.

All of those things also make it great for using with students, which is part of the reason these little boxes wound up at Los Medanos. Here's Jill Bouchard, our instructor from before. She teaches biology and co-chairs the department of biology at Los Medanos College.

Jill Bouchard: We have embedded research in all of our BIO 21 sections. So some students get out in the field and do field type studies. Other students wanna look at the effects of different chemicals on plants in the labs, so that's one reason why I really like EcoFABs.

Menaka: With EcoFABs, students can start with a seed, then study it as it grows. They can change the nutrient mixture in the liquids they feed plants, their media, and expose the plants to different microbes. Then, they can take photos and measure root lengths. Jill sees a lot of benefit to all of that for her classes.

Jill Bouchard: Studies show that it's really beneficial to have research embedded into courses. They feel this ownership over, like this is their project, right. Also I think to help build their identity in STEM, right? They're very interested in STEM. And so I think having that opportunity to do the project-based learning is important.

Menaka: For many of Jill's BIO 21 students, her course is their first research experiment. So they're often a bit surprised by the process. Here's Heath Galiwango. He was TAing for the course I visited. But he took BIO 21 the first year they piloted these experiments in EcoFABs, and he said he was pretty surprised when Jill brought them into class.

Heath Galiwango: I was like, how are we gonna grow anything in there ? I was very confused! Because I'm so used to plants being in the ground and not in a container. So it was something that I wasn't expecting to work with, especially ‘cause we were the pilot program and I didn't know what EcoFABs were.

Menaka: In this year’s BIO 21 course, a lot of students mentioned starting out with similar ideas.

Kylie Johnson: Whenever I thought of being able to study plants, I always thought of, oh, they have to have soil, they have to be in the ground.

Joseph Esquivel: That was my first thing too, I was like — I thought plants needed soil to grow.

Marlena Madrigal: From the first look of it I was like, how are we even supposed to put our seed in there? You know?

Kylie Johnson: But with the EcoFABs it really changes that.

Joseph Esquivel: The way that they're designed is so that you don't need the soil. You could just put the water in essentially and they'll grow without it.

Marlena Madrigal: It's honestly super cool how we are able to see the root growth, the shoot growth, you know, bring our research to life with these.

Menaka: So working with EcoFABs turns out to be very interesting for students. Which makes sense, because remember, they’re designed for adaptable, consistent experiments. But still, like every project, it takes time and effort to develop protocols. I also talked to someone from the Northen lab who’s done lots of that work, both for this lab course, and other programs.

Ying Wang: My name is Ying Wang.

Menaka: Ying started as a postdoc in the Northen Lab in 2019. She studies soil microbiomes, to understand what makes those ecosystems store carbon, or release it into the atmosphere. She knows first hand that EcoFABs can spark lots of interest.

Ying Wang: Actually, EcoFAB was the thing that attracted me to our lab.

Menaka: While she was working on her PhD at UC Santa Barbara, Ying saw a paper from Trent Northen’s lab about how plants and microbes interact in the soil, around a plant’s roots. She saw another paper about EcoFABs.

Ying Wang: And I reached out to Trent and then wanted to use EcoFABs to study plant microbe interactions.

Menaka: So she wrote a proposal and joined the Northen lab. Once she was there, she started focusing more on the microbe part of the plant-microbe interaction. Ironically, she didn't work with EcoFABs all that much.

But then, she heard about a program that Berkeley Lab runs for local high school students. It's called the Berkeley Lab Director's Apprenticeship Program. Bay Area high school students apply to the program, then take on hands-on projects. So Ying took the chance to develop an experiment for those students with EcoFAB 2.0. That followed the pilot that another former Northen Lab postdoc Lauren Jabusch had started. And Ying's pilot went well.

So a bit later, when the idea to create a course activity for BIO 21 came up, Ying was in a great spot to help out. She shared instruction materials, protocols, and teaching videos with Jill.

Ying Wang: We started the conversation back in 2021.

Jill Bouchard: And it took some time, especially, because we were still fully online.

Menaka: So there Jill means – because of the pandemic, students weren't coming into classrooms. They were working on setting up these experiments, when it wasn't clear yet when students would be back in-person.

Ying Wang: And we met several times, over the year, to help her to brainstorm and design her course. And she actually came to JGI last year, and met with several people from our lab and learned how to work with EcoFABs.

Jill Bouchard: And then we finally, after, I think a year and a half? Couple years – we piloted last semester, so we had the EcoFABs, and we did it.

Menaka: Success! And here we should mention, this was a team effort. Several other members of the Northen lab helped get this program off the ground. In particular, Vlastimil Novak shipped the devices over and gave lots of protocol advice. And that collective effort paid off. Both Jill and Ying mentioned how neat it was to see students bring their own interests into these projects.

Ying Wang: I remember when Jill took this protocol and then presented it to her students, some of her students also were interested in climate change. So, they set up a separate group to look at the effect of increased temperature.

Jill Bouchard: Anytime I think we can link their projects to climate change, they're really interested in that.

Ying Wang: And I think that's just really, a really nice way to encourage the students to explore, you know, different ideas and learn how to design experiments to test questions and hypotheses.

Menaka: The students in these activities are cutting scientific teeth.

Ying Wang: I have been surprised and also impressed by the creativity of the students. And that demonstrates to me, if you expose those students to those research projects, even though they may seem small — but actually, can play an important role in encouraging them and stimulating them to, you know, potentially pursue biology or STEM careers in the future.

Menaka: Jill mentioned that what students take away from these experiments runs the gamut. In an undergrad bio class, of course, some groups need more support getting their experiments and hypotheses together.

Jill Bouchard: Then there's always groups that they wanna think outside the box. Like, can we do this? Can we do something different? And so I really like that. I wanna support the students that need that guidance, but also give the students that want to be free and explore — that opportunity too. SO I like that. And we're doing it again, this semester.

Menaka: So we'll head back to BIO 21 to hear how this semester's projects are shaping up. First, a quick break.

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Allison: In this episode, researchers from the JGI are helping out with ideas and supplies for the BIO 21 lab at Los Medanos College. But you don't have to take it from us. Here's Gabby Canel:

Gabriela Canel: It feels very sciencey, so I feel very, very scientific. It's something very new. So we would definitely appreciate the partnership that you guys are doing with us. Yeah. Something that I don't think we would've been able to do without the project, so Yeah.

Allison: And Jill Bouchard.

Jill Bouchard: I've been really pleased with the support and the communication from JGI. Especially, I know how busy postdocs and PIs are. I was a postdoc, my husband's a PI and I just really appreciate the dedication that it feels from them that they have to do outreach. I love connecting with, you know, labs that are at the cutting edge, they're doing cutting edge research and they're supporting us to bring that to our students or to my students. And so I've really appreciated the support from JGI.

Allison: And all year long, we support research scientists around the world to answer questions related to bioenergy or environmental issues. If that's you, and you have a research question you'd like support on, check out our proposal calls! jointgeno.me/proposals

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Menaka: This is Genome Insider, from the JGI. Where we left off, I'd introduced Ying Wang.

She’s helped set up educational EcoFAB programs. And one of those programs is Jill Bouchard’s BIO 21 lab, where students spend weeks growing a model grass, Brachypodium,

Like all lab projects with living things, these experiments can take a bit of troubleshooting. And Jill works with students on that. Here she is talking to one of the lab groups.

Jill Bouchard: Is that, that’s the media you wanted in here, ok

Menaka: The EcoFABs are well designed, but there’s no such thing as a perfect instrument. They can leak, media can dry out, or, on the flip side, unplanned mold can make its home in an experiment. But running into problems, is another real part of science.

Jill Bouchard: I remember I used to hate hearing this in labs, why things didn’t work, and then working as a scientist for a long time — sometimes I spent a year troubleshooting an experiment. And then, “Oh, finally! After three months I figured that out, now how do I stain it?”

Menaka: Jill stands by how important this is for students to see.

Jill Bouchard: This part, is, I think, the part of science that you don’t get in labs where it’s outlined for you,

Students :Yeah, oh sure,

Jill Bouchard: Here’s the media, here’s everything you do, you put it together and here’s the result. And I think those types of labs are really important for learning concepts, but this is, this troubleshooting part of science and trying to figure things out, like what — I’m really curious, this happens every time, what is it? Right, this to me, is very realistic of what it’s like in a lab.

Menaka: And that’s a pretty unique experience to get from an intro bio course.

Jill Bouchard: So what I hope they're walking away with is a realistic idea of how science is done.

Menaka: It’s something Jill wants to offer, especially, to students at a community college, like Los Medanos.

Jill Bouchard: Many are gonna transfer to four year colleges and they may want to work in labs. I hope that they feel they're a little more prepared.

Menaka: Not every student who does these labs likes working on experiments — but they still walk away with a better understanding of the process of science.

Jill Bouchard: And then I've had other students over the years, they're like, I didn't know I liked research, but then I really like this. I was up for three hours kind of investigating that.

Menaka: And that was something I heard in class too.

Kylie Johnson: I haven't really been into this kind of stuff until I got into this class and being able to see it from start to where it is now is actually pretty cool.

Lauryn Painter: I'm a bio major so I thought I, you know, I'd like to work in a lab one day.

Heath Galiwango: First of all, I never thought that I would ever, ever want to be the research experiment type. I didn't think I'd have the patience for it. And in fact I do, which was really nice too. 10 outta 10 experience I would say, yeah.

Menaka: So it won't be surprising at all – that Ying has heard very, very similar feedback from the other programs of students she's worked with. Here she is.

Ying Wang: Last year when I was teaching the high school students, and one of the students actually asked me, what does EcoFAB mean? And I said, it's 'cause the full name is Fabricated Ecosystem. And they actually told me that they thought it was EcoFabulous because the research project was just fabulous. So that really made my day, made my year actually. Yeah.

Menaka: That's great. I did have another student say "EcoFabulous" to me at Los Medanos, so that makes sense.

Tina Basu: It's fabulous.

Ying Wang: Oh, that's awesome.

Menaka: Look at us, coming all the way full circle.

Menaka: I think it's so neat that the EcoFAB is a technology that works for scientists who are trying to collaborate across the world, and study plant microbe interactions — as well as in a high school or college classroom.

Ying Wang: Yeah, definitely.

Menaka: And there are all kinds of cool developments planned for the EcoFAB technology – there's an EcoFAB 3.0 that will fit a foot-tall plant, and an EcoBot that's meant to run experiments on its own, remotely. When we chatted, Ying was excited about bringing EcoFABs to even more classrooms so more students can get hands-on research experience.

Ying Wang: So what I'm currently doing is to convert the project we already have, to a more standardized teaching module, for example, linking with the next generation science standards, and exploring ways to how we can, best disseminate this resource to broader communities, you know, especially to schools that may not have access to those research related teaching

resources.

Menaka: Yeah. That's so awesome. And I think it's, it's really cool that, sort of how you got involved in the work you are doing is by finding out about EcoFABs, and now you're sharing EcoFABs with the much wider community.

Ying Wang: Yeah. Yeah. I really like how you framed it. Yes.

Menaka: And that’s our episode. I will spare you the sappy pun about planting seeds.

Menaka: So again, that was Jill Bouchard and her students from Los Medanos College. Many, many thanks to Heath Galiwango, Lorenzo Navales, Lawrence Cabansang, Gabriela Canel, Joseph Esquivel, Tina Basu, Sergio Gonzalez, Marlena Madrigal, Lauryn Painter, and Kylie Johnson.

Ying Wang will actually be moving on from the Northen Lab soon – in January 2024, she’ll join the Department of Soil and Crop Sciences at Texas A&M University as an Assistant Professor. Big congratulations to Ying, and we’ll plug – she’s recruiting students and postdocs. You could reach out to her on LinkedIn and we’ll link there in the shownotes.

The Northen Lab has developed EcoFABs, and uses them to support activities across the Biosciences Area at Berkeley Lab. That includes Environmental Genomics and Systems Biology, the Joint BioEnergy Institute, and the Joint Genome Institute. EcoFABs are available to JGI Users, as well. The entire Northen lab has helped out in developing EcoFABs and supporting these programs. Peter Andeer designed the EcoFAB 2.0 device, and Vlastimil Novak played a key role in making that device available for this pilot program at Los Medanos.

Outside the Northen lab, David Gilbert and Kris Bouchard were instrumental in the initial conversations that brought this pilot to be.

If you want to find out more, check out our episode description. This class was a pilot program, with plans, eventually, to expand beyond one class.

This episode was written, produced and hosted by me, Menaka Wilhelm. I had production help from Graham Rutherford, who helped with recording on site, as well as Allison Joy, Massie Ballon, Ingrid Ockert and Aliyah Kovner.

We had music in the middle of this episode by Cliff Bueno de Mesquita, who’s a multitalented postdoc at the JGI.

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Genome Insider is a production of the Joint Genome Institute, a user facility of the US Department of Energy Office of Science located at Lawrence Berkeley National Lab in Berkeley, California.

Thanks for tuning in – until next time!