JGIota: Looking back at how our cow rumen study drives higher learning

Allison: And now a JGIota, a snippet about JGI-related research tools, people, discoveries and more. I'm Allison Joy, your host for this Iota.

For 25 years, the JGI has been supporting genomics research, and in honor of this year's 25th anniversary celebration, we're taking a look back at all kinds of species JGI researchers have studied.

Today in part two of our Guts 'R' Us series, we're talking about a JGI data set from cows' rumen, their largest digestive compartment, and how that data set of essentially gut microbes has fueled a genomics crash course for undergrads across California. Our course instructor is Matt Escobar.

Matt Escobar: I'm a professor in the biological sciences department at California State University, Santa Marcos. My background is in plant molecular biology and plant development.

Allison: And here's a bit about that course based on that cow rumen dataset.

Matt Escobar: So I got a big freezer box full of cow rumen samples, and that's the starting material for the students. So , I always warn them, 'Hey, you're, you're opening up plant material that sat in a cow for three days. This isn't gonna be the most pleasant smell, but you're gonna get really cool DNA out of it.

Allison: But rumen samples aren't the most appetizing to work with, shall we say.

Matt Escobar: And so I explain to the students that it's basically bacteria-covered, half-digested corn. And yeah, I convince them to be excited about that.

Allison: And I guess that works. So those cow rumen samples that Matt's students open up, they came from a JGI-supported research project. And to see why those samples have landed in classrooms, let's talk a bit about why they were collected in the first place.

Over a decade ago, Mattias Hess, a former JGI postdoc, led a study working with researchers from the University of Illinois to look at how a cow's rumen microbes break down plants' cell walls.

These materials are called cellulose or hemicellulose, and they don't really have any nutritional value to the animal until they are degraded in the cow's rumen, releasing sugar. And the sort of breakdown these rumen microbes are capable of provides insight into how humans could break down the same kinds of materials for biofuels.

Here's Mattias, who's now at UC Davis.

Matthias Hess: The goal at that time was really to find enzymes that would help us break down biomass, and we wanted to find these enzymes that can do that in the rumen and transfer that into industry, specifically to generate biofuels.

Allison: By taking a look at the genomes of those microbes, Mattias came away with over 27,000 genes associated with enzymes that could be digesting these materials.

Matthias Hess: What's really important to note is that these enzymes that we discovered were not previously known. And we predicted them to have the ability to break down these plant materials into these small molecules. And that was very novel.

Allison: The thing about these 27,000 genes was that they were merely predicted to have a role in breaking down these hardy plant materials. Only 90 of those genes had actually been tested for the carbohydrate-active enzymes that help break down tough plant cell walls. So that leaves the remaining genes as great test subjects.

And this is where our instructor, Matt Escobar comes back in, because in 2015 Matt happened to be developing a special lab course meant to introduce undergrads to research. It would give them a chance to do experiments and tackle real open questions.

Matt Escobar: This course would go on to become sort of my baby. I'm the only person that teaches the lecture and the lab, and I really wanted to kind of make it my own and make it something that would grab students' interest.

So as I was developing the lab, I thought back to this paper by Matthias Hess and colleagues at the JGI, and I wondered whether it could essentially be recreated or applied in the classroom with undergraduates.

Allison: Because all data generated by the JGI is made public, really anyone with the tools and the intention could start digging into what exactly these genes do. Matt's students would be able to work on genes from the giant data set and test whether or not they actually encoded carbohydrate-active enzymes. So he got in touch with Matthias who happened to still have those same cow rumen samples from the original project, which he then shared.

Matthias Hess: Of course, I was really excited that he would take the science and the findings that we generated in that study and I was just very excited about seeing how that would basically make it into a syllabus.

Allison: So Matt started with one aspect of the paper: expressing potential carbohydrate active genes in *E. coli*.

Matt Escobar: It probably took me a whole summer to figure out how it could be broken up into bite size pieces for undergraduates, that they could kind of grasp, understand

and carry out the characterization of a new carbohydrate-active enzyme. And so, basically I was able to do that with some help from Matthias.

Allison: Matthias also helped Matt hone in on where students would begin their experiments.

Matt Escobar: I got some help from Matthias in terms of identifying potential targets with glycoside hydrolase five, glycoside hydrolase eight, and glycoside hydrolase nine domains — all of which are characteristic of cellulases. And so that was basically our starting point.

Allison: With samples in hand and targets identified, Matt now had an up-and-running course based on these rumen enzymes. He and his students used what's called a PCR process to target and copy a specific gene they believe could encode the kind of enzyme they're looking for.

These Petris dishes are called a carboxymethylcellulose (CMC) plate assay, a test for activity of the enzymes. The clear areas indicate an active cellulase enzyme: The plate on the right in the image below shows that one of the genes that Matt's students is testing encodes a novel enzyme that can efficiently break down cellulose.

Matt Escobar: We have a really cool enzyme activity assay. It's very visual.

Allison: The samples sit on pink-stained Petri dishes…

Matt Escobar: big chunks of the, the pink stain go away if you've got an active enzyme. So it's a very obvious yes or no.

Allison: And everyone is hoping for an active enzyme.

Matt Escobar: You know, everybody's hypothesis going in is, 'Yes, my gene encodes the cellulase that's going to be incredibly efficient at breaking down cellulose, and it's going to change the world because it's going to revolutionize biofuel production. It's a

different experience because you have to explain to the students that, you know, we are doing new work and your hypothesis really, really, really might not be supported.

Allison: Matt says that's part of what makes courses like his so important to fledgling scientists. They're called course-based undergraduate research experiences — or CURE — and the idea is to give students as close to real-life, hands-on career experience as possible with all of its ups and downs, trials and tribulations, disappointments and validations.

Matt Escobar: That's kind of what maybe differentiates a CURE, a course-based undergraduate research experience , where you're working to answer a question that has never been answered before, you're creating new scientific knowledge. I think that's kind of par for the course.

Allison: Since Matt launched his course, the JGI has helped him expand the curriculum beyond CSU San Marcos. There are now faculty at three other universities — San Jose State, CSU Monterey Bay, and Cal Poly Humboldt — teaching variations of the course. They're all part of CSUPERB, or the California State University Program for Education and Research in Biotechnology, a cohort of 23 campuses who participate in biotech research.

Matthias Hess: I think it's really exciting to see how that data, it's not only made accessible to the scientific communities, but also to students and then specifically , to students who might not have, necessarily, the resources to do this otherwise.

So I'm really excited about that course. And then also really that the JGI is providing the support, system-wide, California State University systemwide. I think this is huge, and so I'm really excited about this.

Allison: And that's a wrap on this JGIota but if you're yearning for more rumen, make sure you listen to last month's episode on the Hungate1000's collection of rumen microbe sequences. We've also got a number of highlights about other discoveries the JGI has made in its 25-year tenure on our website and YouTube channel. There's a link in the show notes.

This episode was written and hosted by me, Allison Joy. I had production help from Menaka Wilhelm, Massie Ballon, and Ashleigh Papp. If you liked this episode, help someone else find it. Tell them about it, send a link over or leave us a review wherever you're listening to the show.

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Thanks for tuning in and until next time.