Transcript

Speaker 1: You're tuned in to 90.7 FM, k a l x Berkeley. My name is Tesla Munson and this is the graduates, the interview talk show where I speak with UC Berkeley graduate students about their work here on campus and around the world today. I have the Fortune Ne, the pleasure of being joined here by molecular biologist, Heather Bruce, department of molecular and cell biology. Correct. Yup. Welcome. Thanks for being here. Thank you for having me. That's my, it's my pleasure. So I guess we should start by introducing, I've only had one other [00:00:30] MCB as we call it MCB student, which was still club phases as you, uh, we were talking about earlier, but Phil's great. Yeah. So what, could you just refresh us? What is molecular and cell biology in which one of those do you do or are they the same?

Speaker 2: Um, I, I think, uh, I would say that, um, molecular in cell biology are kind of a level of looking at things. So it's, you know, it's not at the level of the organism, you know, so below the organism [00:01:00] and behavior you would have like kind of the cell level and like the tissue level. Um, and then below that you would have inside the cell you have like protein interactions and like protein folding and stuff. So that would be biochemistry. Okay. So molecular biology is kind of in between those two. And so the kinds of like questions that molecular biologists ask are, you know, how does development happen? How does embryogenesis happen? So, you know, for an embryo you're thinking about how do cells [00:01:30] move in a sheet in order to like form a limb or something like that. So I'm in development,

Speaker 1: you're in development. Very nice. And uh, are these invertebrates

Speaker 2: or, yeah, I'm in invertebrates. In my Undergrad I did snails and then for graduate school I'm doing crustaceans.

Speaker 1: Okay. So all invertebrates. Yeah. So tell us a little bit about your undergrad. You did research.

Speaker 2: Yeah. And where was your Undergrad? Uh, University of Arizona in Tucson. Very nice. Are you from to uh, Arizona or, no, [00:02:00] I, so I'm from the bay area. I grew up in Sunnyvale and mountain view. And then, uh, when I was 10, my parents moved to Korn Ville, Arizona. Wow. Great. They're real. Please. There's no corn in there. Even better. Yeah. And then I did like high school and um, community college there. And then I transferred to University of Arizona and then I, I came back to California as soon as I could. Yeah, no, I can understand why I never want to leave and you can't [00:02:30] tear me away. Awesome.

Speaker 1: Can I ask a what, what was the transition like from community college to you, Arizona?

Speaker 2: It was, I was definitely really scared. I was worried that, you know, I wasn't going to be smart enough and you know, I definitely had the whole imposter syndrome thing going on. But like, you know, I wasn't, you know, everyone else was going to be really well prepared cause you know, they'd had all this like prep courses and they knew all this stuff [00:03:00] about how to do college and, but when I got there, I mean it was actually a lot like community college. It was just bigger classes. And I think what I did to kind of help myself was I just sat in the front and then that made it feel like, you know, I wasn't, I was kind of in a small class cause I was like right next to the teacher and then I felt like I could just, you know, I was just having a little conversation with a teacher and then that made it feel less huge and intimidating.

Speaker 1: Yeah. Awesome. And obviously you were not [00:03:30] an imposter because here you are at one of the best schools in the country. So I hope not. Definitely. I'm still fooling though. I yeah, that impostor syndrome never goes away. It's hard. Yeah.

Speaker 2: That's really hard. Yeah. Well topic for another day, but so did you do this molecular or developmental work in Undergrad as well? So I'll give you the backstory. So when I was in community college, I was working in the biology lab, like as a ta and stuff. And for my birthday they gave me this book called endless [00:04:00] forms, most beautiful from Sean Carroll. That's a great book. Yeah, yeah. And I was like, oh my God, this is, this is amazing. I, we know how to like make animals and we can think about, you know, how to put them together. Like they're little like circuits and stuff. So I thought that was really amazing. So I knew I wanted to go into some kind of, uh, you know, evolutionary developmental biology. So when I transferred to u of a, they have, there were two programs, there was ecology and evolution, and then there was molecular [00:04:30] biology.

Speaker 2: And since ecology and evolution had evolution in it, I transferred into that one because that seemed, you know, like where Eva Eva would happen. But when I first transferred there, it was like fieldwork. And I was counting like the seeds of little desert plant plants. And it was like, it was cool, but it was not evo evo. So then, you know, I think six months in I transferred into MCB and then I started in a Dr Lisa [inaudible] lab [00:05:00] and she works in Evo Divo and she works on snails. So my project was to characterize the role of the hawks gene post to, in the development of the mollusk shell. And so that's interesting because the mollusk shell is, they call it a morphological novelty. And that sounds kind of jargony. So what is that? So there are things in evolution where you can tell kind of what the ancestral form was [00:05:30] like.

Speaker 2: If you think about our hand, you know, going back it was like, you know, a reptile hand or an amphibian hands or a fish fin and stuff. But there are other things where, you know, the ancestral form isn't obvious. So if you think about mollusks like snails and clams, their ancestor looked more like kind of a Leech and it doesn't have a shell. So it's like, well, where did that Shell come from? We're used to thinking about evolution being kind

of tinkering with an existing [00:06:00] object. But if that trait doesn't exist, what do you tinker with to, to bring it into existence. So, so that's why I find novelties really interesting. And so where did the shell come from? Did you, did you know [inaudible] I know I built it up. No. Um, yeah, I actually, I was doing a few different experiments and none of them work.

Speaker 2: That's very common I hear. Yeah. Yeah. And, and I actually, I found out later she told me that one [00:06:30] of the reagents that I was using had gone bad. Oh, I was, why nothing was working. And I was like, oh man. So how do you go about characterizing the effects of a gene? What does that mean? So for the snail, the snail gene, first we wanted to see, well, is this gene expressed in the tissue that gives rise to the shell? You know, so you wanna you want to correlate, you know, the genes expression with like the tissue think it's involved in. And so to do that, [00:07:00] you do an experiment called an [inaudible] that shows you, it makes a little color wherever the gene is being expressed. So you can kind of see it. And then the next thing you would want to do is figure out, you know, well, does it have a function there?

Speaker 2: So it could be expressed in that tissue, but it might have nothing to do with the shell. And so to do functional tests, you can either take away the gene, you can knock it out. And so you could see, well if it doesn't have this gene, maybe the shell doesn't form. [00:07:30] And so then you could say, Huh, this gene is necessary for forming shell. Another thing you can do is to take that gene and put it in a place where it's not normally found. So like in the head or something like that. And then you can see, well if I put this gene in the head, does it make a shell on the head? And then you can say, if it does that, okay, well this, this gene is sufficient to make shell if you have this gene. That's all you need in order to get that, that Shell program going.

Speaker 2: [00:08:00] So, so it sounds like you're kind of talking about two different time slices, right? Cause if you're doing it in C2 then you would want to like look at a very specific time to see if the gene is expressed. But then if you're doing, can we make a shell that you're like letting the animal keep growing and see what happens or am I getting that right? No, that's pretty good. So I mean within [inaudible] you can do a whole group of embryos and so you can have a bunch of different time points so you can have, you know, embryos that represent like, [00:08:30] you know, early time points all the way to hatching or whatever. And that will kind of that we'll let you follow the expression of that gene from like the very early, you know, first few cells all the way to like the finish tissue. But yeah, with, you know, if you want to see the, they call it like the phenotype, kind of the result of the what the physical animal looks like, then yeah, you would do like the very after it hatches and, and see if you

Speaker 1: have a shell. Very nice. So if you're just tuning in, you're listening to the graduates [00:09:00] here on KLX Berkeley. My name's Tesla Munson. Today I'm speaking with molecular biologist, Heather Bruce and a, yeah, developmental biologist I should say. So

we heard about the snails. I was all in your undergrad work. What are you doing now? Are you still in development?

Speaker 2: Uh, yeah. So now I'm, I'm still in development and I'm still in invertebrates. So right now I'm working in a crustacean and it kind of looks like a little shrimp. It's called par high, Ellie, Hawaii Ansys. Does it have Hawaii for a good reason? [00:09:30] It does. It comes from Hawaii. Awesome. Yeah, they're actually, so that genus I believe is found, you know, all over kind of tropical type areas. And that group of crustaceans is, I think found everywhere. Like on every continent. They're both marine and freshwater. And there are also some in the Antarctic. Wow. Yeah. So my Pi has gone to the Antarctic I think too. It's very cool. Yeah. Or we've gotten some from from there. Yeah. So. So yeah, so it looks [00:10:00] kind of like a little shrimpy guy. And right now I am kind of, the title of my project is to characterize the genetic basis of appendage diversity in the crustacean per Hailey.

Speaker 1: Okay. So the genes that make different kinds of arms and legs basically, do we call them arms and legs and shrimp? Can we do that or should we just stick to appendage? You can do legs, legs. Until I do legs, I say legs all the time.

Speaker 2: I like airing on the side of just use kind of a regular [00:10:30] word. And some people in the lab like to call them like plea a pods and perio pods and it's like no one, no one, you don't know, you don't know their lives. They have a whole bunch of different like types. So they have antennae and like weird little mouth legs, mouth parts, and they have claws and they have forward walking legs and backwards walking legs and little feathery swimmer rats. If you think about a lobster and kind of think about that. And then they have these kind of spiky [00:11:00] stout anchoring appendages on the, on the abdomen. This is all in one animal. They have all these kinds of things. Yeah. So that's actually why it's a really great system to study this question. So all the legs I just mentioned are developmentally related.

Speaker 2: So when the animal makes legs, um, it first makes this little tiny like limb bud, and then it's like, okay, this is going to be a leg. Now what kind of leg is it going to be? So [00:11:30] there are these genes called hawks genes and they tell the leg, okay, you're in the head. Okay, you're going to be an antenna. You're around the mouth, you're going to be a mouth part. Um, and so it's these hawks genes that are telling the legs, you know, kind of what to be, but they all start out as like, you know, okay, you're set aside, you are like tissue and so you can actually um, mess with the hawks genes so you can knock them down. Or Mis express them in different places where they're not normally found. So if you [00:12:00] knocked down this one hawks gene called abdominal B, then the feathery swimmer rats, they're kind of, they're like small and like delicate looking.

Speaker 2: Instead of developing like a swimmer at, they develop like this big long walking leg. And so you can, we call it transform the identity of that leg into the identity of another leg. And so the reason crustaceans are really interesting for this is because since all of these

legs are kind of developmentally related, like the ancestor of all [00:12:30] crustaceans probably looked something more like a centipede. So it had a whole bunch of legs that were all the same type. And then in the crustacean lineage that all those different leg types were modified to do a whole bunch of different things. And so looking in a crustacean essentially lets you look at a whole bunch of very different leg types, kind of different evolutionary trajectories in a single animal.

Speaker 1: No, that sounds pretty cool. So again, is this the same sort of in C2 and expression [00:13:00] experiments or development as well?

Speaker 2: So this is kind of an NC too on like a massive scale. So what I'm doing is taking the embryo and cutting it up into different segments. So I'm, I'm cutting out like the claws and the summer ets and the walking legs and stuff. And then I'm doing this, I'm sequencing all the genes that are being expressed in each of those body regions and then asking, okay, well are there any genes in the claws [00:13:30] that are not expressed or differently expressed than they are in the walking legs or in the intent a or something like that. And then I'm looking for genes that are differentially expressed, so then I can say, okay, well it looks like, you know, there's something going on here with these jeans. So that's essentially an NC to, except I'm doing it by sequencing all of them. But that's just, you know, that doesn't really tell you if they're functioning there. So then in order to see if those genes actually have an interesting [00:14:00] function, I'm going to knock them out with this new technique called CRISPR cas nine. And that's, it's a way of like knocking genes out and stuff. But it was developed by Jennifer Doudna who's here and it's an amazing, amazing technology. She the one who you

Speaker 1: just got that award, I'm sure I was reading. She's got a lot of awards. Yeah. Nice. So, um, when you say knock out, maybe we should get into that a little bit more. Does that mean like replace [00:14:30] it with something else or just make it stop working or make it stop working? Yeah. So that just means you like, yeah, you cut the gene out and so the, you must have like little target. I don't, you know, I don't deal with anything this small. So how do you like how do you target a part of DNA and then like remove it?

Speaker 2: The way that you do it is you make a cut in the DNA, like wherever you want. And then the way the a cell repairs [00:15:00] that cut, often it will repair it but not like perfectly. And so it will delete, you know, like a few base pairs in there. And then deleting those few base pairs can like often disrupt the entire gene because like when the gene is being red, it's red in like a three base pair frame. And so if you cut out one of the base pairs, then that entire frame has like your reading frame has completely shifted and now you're making kind of this nonsense product. Oh, [00:15:30] interesting. Yeah. Nobody likes nonsense. No. So what, uh, what do you think are like the broader implications of this in terms of what the public might really be interested in? Yeah, I mean I w I think that's a really good question and I feel like when people ask me, you know, well, what, what's, you know, the question that you just did, I think people think that I'm actually interested in, you know, wow, how do I make this little crustacean guy?

Speaker 2: Wow. The legs are, [00:16:00] they're so interesting just for their sake. But that's actually, I don't think anyone's really interested in that. Like you're always using this particular crustacean or whatever animal you're using to answer a much larger questions about evolution or biology. And so kind of the questions that I'm interested in are how to build animals. Like how do you build animals from genetic circuits and then how do those genetic circuits change over time in order to create new physical forms [00:16:30] in order to create all of the diversity that we see around us. So if you think of like a centipede and a giraffe and an octopus and a flower or any plants in that plant person, you know, they're all just incredibly different looking. And the reason they look different is because they express different genes. So yeah, I think, I think it's really fascinating to figure out, you know, how, how was this animal made and you know, if you want to make something kind of similar [00:17:00] but maybe like longer legs or you know, with horns or without horns, what are the genes that you need in order to do that?

Speaker 2: And so the, where my research fits into that is, so since all of the legs in the crustacean are kind of evolutionary, evolutionarily and developmentally related, they kind of represent, you know, a whole bunch of different physical types, but you can study them in the same genetic background. So [00:17:30] we might be interested in, you know, how do you go from a fish fin to our hand or a horse hook or like a puppy's hand and you know, we could compare all of their jeans and stuff and different expression patterns and stuff, but there are going to be a of jeans that are just vastly different between, you know, these very distantly related animals. And it's going to be really difficult to find meaningful comparisons because just like all [00:18:00] of the genes are going to be really different. So then it's not just about invertebrates though.

Speaker 2: Cause you mentioned flowers and drafts. So obviously there's like commonality between these, even if their genes are very different, there are some like large scale patterns that you could hope to pull out or, or is it more about comparing, uh, the appendages within a single work type of organism and then having a better sense of the machinery behind it? Yeah, totally. Totally. So you can compare all of these different [00:18:30] appendage types within one animal and then you can see, okay, well they all started out the same, but then they've become very different during development and you know, they have different outcomes like a claw in the summer and so on. And so because you're in the same genetic background, you can make meaningful comparisons between plause and swim rats and stuff. And so if I compare all the genes that are expressed in a summer at versus a claw, I know that, you know, all of the kind of basic [00:19:00] housekeeping genes, those are all going to be the same because it's in the same animal.

Speaker 2: But whenever I see differences, it's not because it's like huge evolutionary distances between like a fish and us. I know it's because, you know, these are probably the genes that are making a club versus making a swimmer. So we've said making animals quite a bit. All right. Do you want to make some animals or how do you feel about this idea of making ideological organisms? I think that would be amazing. That's actually kind of why

I got into [00:19:30] this. I don't think we're going to be able to tinker with animals in any real meaningful, awesome way. But like in the future, far, far off in the future, I think it would be so awesome if we could make like griffins and Unicorns and crazy things would definitely be crazy. Yeah. So what, how does this play into like GMOs? I mean you said that word before, like to me personally.

Speaker 2: Yeah. Cause that is genetically modified [00:20:00] organisms seems close. Yeah, no, it totally is. I mean we are, in my lab we're doing this CRISPR cas nine to knock out genes to look at their functions. So that's totally, that's, they're genetically modified their GMOs and we don't eat them, but we could, I guess, I don't think they would taste very good. So, so yeah, I think people talk a lot about GMOs and it's a pretty like heated discussion usually. And yeah, I guess as a molecular biologist [00:20:30] and reading a lot of the papers on genetically modified food and stuff, it's safe. And I also feel like if you care about the environment and if you care about feeding all of the people in the world, then you should eat GMOs. So I mean I just took this genome engineering genome editing seminar course and like the, the final class we discussed GMO food and I volunteered to kind of lead [00:21:00] the discussion.

Speaker 2: So I like boned up on a whole lot of papers. So I think there's this one particular review that's pretty recent. I think it was a few years ago from Snell s n e l l et Al. And they did this exhaustive review of whether or not there are any negative human health effects of consuming GMOs. And I mean the paper is almost boring. And how like, you know, it just goes on and on. Like [00:21:30] this study found that there were no health effects. This study found that there are no health effects. And then this study tried it a different way and this study did it in different animals and they looked in like cows and pigs and chickens and coils and mice and rats and fish. They did fish to all these different feedings studies to see, you know, you feed animals, genetically modified food, you know, do they get cancer more, do they have behavioral effects, do they have like [00:22:00] weird things going on with their tissue or their liver or their kidneys and stuff like that.

Speaker 2: They also did multigenerational studies. Maybe it doesn't affect, you know, that animal, but maybe it's offspring or maybe it's offspring's offspring and so on. And it was just this exhaustive review of so many papers and they just did not find any health effects on these animals from consuming a GMO food. So I think that's like one of the major concerns that people have. Like is it safe to eat? [00:22:30] And then another concern is are there any environmental effects of GMOs, like crop plants and stuff on the environment? And that was a little like more difficult to find papers on. I tried to restrict my search only to papers where they had their phd from, you know, a well known university and they were not funded by a corporation or something. So it was just public funding and it was really hard to like [00:23:00] search through everything and like confirm the, the funding and stuff like that.

Speaker 2: So I did find a couple and I found a review that was pretty good. And so it compared fields that were not sprayed with any pesticides or herbicides and then a field that was

sprayed with pesticides and then a field that was only had the bt gene. Um, and that's the one that's the insecticidal one. And they wanted to look at like insect diversity. Like if [00:23:30] you, if you have these bt crops that are insecticides, are they really affecting the diversity of insects in the like surrounding area. And they found that if the, the plot that was not GML and was not sprayed for pesticide had slightly more insect diversity than the plot that was bt and not sprayed for insecticide, but not spraying for any insecticide is not realistic. If you [00:24:00] don't spray for anything, your entire crop is going to be gone. There's like a really dramatic picture of cotton especially.

Speaker 2: And there was a GMO field right next to one that was like not GMO and not sprayed for anything. And it was like a nuclear explosion had happened on this, like not sprayed one. There was like no cotton, there was just all dead. So it's not really realistic to not spray. Okay. So if you compare the bt crop, um, that's not sprayed to one that is sprayed. The bt one actually has a lot [00:24:30] more insect diversity in it, which I mean kind of makes sense because if you're just spraying haphazardly and like everywhere, then the insecticide is gonna kill anything that the than it gets on. But for the bt, since the insecticide is in the plant itself, in techs actually have to consume it to, you know, in order to get the effects. And since a lot of insects aren't going to eat the crop, like monarch butterflies aren't gonna eat corn, they, they want to eat milkweed. So I mean that kind [00:25:00] of, that makes a lot of sense to me that GMOs are actually better for the environment than just spraying with pesticides and herbicides.

Speaker 1: Yeah, no, I, you certainly convinced me you made a very strong argument. Yeah, it's, it's interesting. Um, all the different things. So why would the funding matter? I mean it's Kinda like, I know, I know it's Kinda like, I, I probably know the answer already, but I'll ask you anyway. Why does it matter if they're funded by corporations?

Speaker 2: Yeah, I mean it, the scientists could [00:25:30] be doing like perfectly good and well designed experiments and maybe they are, but since I'm not a plant biologist and I don't even have a statistics background, I don't have the background to be able to evaluate whether the design was, was good. And so I wouldn't be able to tell if there would be a better way of going about it or if they didn't do the necessary controls in order to try and get a particular outcome. And so I just didn't want to risk that. I just, [00:26:00] I wanted to not even have a doubt that like these results might be skewed a little bit. So. Yeah.

Speaker 1: Yeah. No. Well it sounds like you're doing some really interesting work, Heather, as we sort of wind up our time here on the graduates. Do you have anything you definitely want to get across to the audience? Um, I know outreach is really important to you because that's how we met and obviously these sorts of large scale issues about GMOs are important to you, but what do you want to leave us [00:26:30] with?

Speaker 2: Yeah, I guess, I mean, I think, I think the GMO thing really is very close to my heart because I mean with, with global warming and you know, having an 7 billion people in the world and trying to feed that many people, we might think that like organic practices

and natural farming and stuff is going to be better, but they're like demonstrably less efficient. There was a paper out from McGill a couple of years ago [00:27:00] that compared, you know, organic practices versus conventional practices and the crops that were raised organically were just, they did not produce as much. And so if you want to get as much food from an organic plot as from a conventional plot of crops, you have to use more land. And that's just not like feasible when we need to feed so many people and we're already destroying so much of the earth. So I feel kind of a moral responsibility [00:27:30] to consume GMO food myself and also to, you know, try and help people understand their place in like helping the environment and helping global warming and, and so on. Well, thank you. It's a, yeah, it sounds like, um, you're doing that.

Speaker 1: Sounds like you're doing that and it sounds like you're doing lots of really interesting developmental work. I think so. Yeah, definitely. That's a near my passion as well. So thank you so much, Heather, for coming on this episode. Yeah. You've been listening to the graduates [00:28:00] here on KLX Berkeley. My name's Tesla Munson. Today I've been speaking with developmental biologists, Heather Bruce and molecular and cell biology here at Berkeley. She's been telling us about her work with invertebrates and developmental tinkering and appendage diversity, and also her passion for spreading the word about GMOs and how they actually aren't bad, in fact, arguing that we have a moral obligation to support them. And if we care about the earth or other people, which I hope we all do. [00:28:30] We do. Yes. Yes. Uh, so thanks again and uh, we'll be back in another couple of weeks with another episode of the graduates here on Calix, but stay tuned until then. You're listening to 90.7 FM k a l ex Berkeley.