Andrew Saintsing: You're tuned into 90.7 FM, KALX Berkeley. I'm Andrew Saintsingg. And this is The Graduates, the interview talk show where we speak to UC Berkeley graduate students about their work here on campus and around the world. Today I'm joined by Aaron Pomerantz of the Department of integrative biology. Welcome to the show, Aaron.

Aaron Pomerantz: Thanks for having me, Andrew.

Andrew Saintsing: It's great to have you here. You study butterflies, is that correct?

Aaron Pomerantz: That's right.

Andrew Saintsing: And you actually brought some butterflies with you. They're really cool looking to all our listeners. Unfortunately, you can't see them, but maybe Aaron can describe them for us.

Aaron Pomerantz: Yeah, for sure. I mean, at least this is what attracted me initially to want to study butterflies because they're very beautiful and they come in all sorts of different colors. And as a scientist I really want to understand where does this color actually come from in the first place.

Andrew Saintsing: So where does the color actually come from?

Aaron Pomerantz: Yeah. So there's a couple of primary different ways, and this really gets into a fundamental question of where does color come from in any animal? And one primary way that animals can produce coloration is through pigmentation. So I think that's fairly intuitive. We produce pigments in our skin, in our hair. So for instance, Melanin is a common pigment that we produce. And if you get tan you're producing more melanin in your skin. But there's another way, which is really fascinating and it's called structural coloration.

Andrew Saintsing: Okay. What is structural coloration?

Aaron Pomerantz: Yeah, so structural color is a really cool phenomenon where light interacts with a surface and then it can bend into a different wavelength. And so, if you ever think of seeing a rainbow in the sky, or maybe light hitting a prism and then bending into a rainbow of colors, this is that same type of property. So white light comes in and if it interacts with a certain surface, then it can bend into a different wavelength. So animals can take advantage of this property. They can produce what are called Nano structures and these are finely tuned, really, really, really tiny structures where light interacts with them and then can produce a certain type of wavelength.

Andrew Saintsing: Okay, so is there no intrinsic color? No intrinsic pigment colors on these butterfly wings? They're just completely producing it by physics?

Aaron Pomerantz: That's right. So they're using physics to produce a color. And there is at least a little bit of intrinsic properties in how the scale is built. So all these scales are made out of Chitin, and these scales cover butterfly and moth wings. So the order of butterflies and moths is called Lepidoptera. And the Latin roots for these means scale your wing. And all of these butterflies and moths have scales that cover them and then those scales act to either produce a pigment or to produce these nanostructures that can produce a different wavelength, and they can interact in combination too. So this to me is the foundation for why I really thought this was a cool system to work on because you can think of a scale as the unit of color.

Andrew Saintsing: So butterflies might have different colors depending on the light you shine on them?

Aaron Pomerantz: Exactly. One of the wings that I brought with me here is a shiny Blue Morpho butterfly wing. I think these are common butterflies that people might think of if you think of like a blue butterfly. So all I'm doing right now is I have one of these morpho wings and I'm just rotating it. And based on the angle of light hitting it, the wavelength comes back as slightly different shades. I'd say, an iridescent blue to more of a purple-y. And then on the other side it's completely brown where they're only producing melanin pigmentation.

Andrew Saintsing: Wow, that's really cool. It looks really beautiful.

Aaron Pomerantz: Yeah, these are very flashy, charismatic butterflies. And it's funny because physicists and mechanical engineers, they've been really interested in these micro and nano structures for a long, long time. And you can take SEM images of these getting electron microscopy, you can look at them in fine detail and you can try and figure out the math that's associated with these physical properties. And then people have taken these nano-structures in nature and then try to apply them. So say things like producing this type of colors that don't fade, producing biophotonics structures. So say you want to make a more effective solar panel or maybe an optical implant in your eye. These are just to name a few of the examples where mechanical engineers have received bio inspiration from butterflies.

Andrew Saintsing: What kind of things can we paint with structural colors?

Aaron Pomerantz: Yeah, I've heard that there are a few companies now, especially car paint that could produce an iridescent color. The cool thing is these structures don't fade. If you leave a pigment out in the sun for a while, it's going to fade over time. You and I have probably walked through the museums here at Berkeley and you see these old specimens that were stuffed decades if not hundreds of years ago. And some of them get quite faded. They look like they've saturated over time. But the next time you look at say a bird in the museum of vertebrate zoology, if it is shiny blue, it's probably not fading. Those little hummingbirds that are iridescent, they're not going to fade over time. And that's because those nano-structures don't fade. Whereas if it's just melanin pigmentation or say like an Ommochrome, a different type of pigmentation, those will fade over time.

So those have really cool inherent properties that you can try and apply for different types of engineering purposes. So that's just a name one with color. The other really fascinating thing about these is they have really cool thermodynamic properties and hydrophobicity properties. If I were to take a drop of water on this, it would just fly right off. So there's lots of really inherent cool properties that these insects have made that we're just barely scratching the surface of trying to understand and then apply.

Andrew Saintsing: You have two samples here. Is the other butterfly the same?

Aaron Pomerantz: This is a different one. This is actually a moth. So the distinction between a moth and a butterfly is a little bit ambiguous. Moths as we know, tend to fly at night. They have fluffy antenna because they're using typically less visual systems and more Pheromones to find each other. But in this case, these are called glasswing moths. They're really large and beautiful moths. And I'm studying these because they actually have transparent windows in their wings. And this is a main focus of my PhD research, which is actually the evolution of transparency in butterflies and moths. So as much as we love them for their beautiful colors, some of them have actually gone on to evolve properties that make them transparent.

There's probably many different reasons why they're becoming transparent. But at least in one case there's an interesting property where they have what are called anti-reflective nanostructures. So in this case, light hits their nanostructures and then passes through more effectively. And this is a really cool application that some mechanical engineers want to apply to solar panels, for instance.

Andrew Saintsing: So why do they want the light to pass through?

Aaron Pomerantz: Yeah. That's one thing that a human would want to take this property and apply it to something else. But why do these animals want to be transparent? There's one really cool example of a group that I study in central and South America and they're called the Glass Wings. It's kind of an interesting group because they live in the Amazon rainforest or under dark canopies. And so the light level is very low in these type of jungle environments. And so to be transparent, it might actually be a form of camouflage because it actually very hard to see, especially when they're flying around and they'll all go into the shadows and they basically just vanish. So it seems like it's an interesting property where they've evolved transparency as a mechanism to go unseen, to be invisible.

Andrew Saintsing: Oh, that's really cool. Can they see each other or do they have other ways of interacting with each other?

Aaron Pomerantz: That's a really good question. And that's something that myself and collaborators are interested in studying. Butterflies, they have the ability to see certain colors that we as humans can't see. So for instance, they can see ultraviolet light whereas we can't see ultraviolet. And there are certain groups of butterflies where they've evolved to have certain types of structural color patterns that are made in the UV spectrum. So they can see it and they'll use it as a way to communicate, but it might be sort of a secret channel that they're using to see one another that is hidden to other, maybe vertebrates like predators.

Andrew Saintsing: Are there any predators of butterflies and moths that have evolved the ability to see ultraviolet light?

Aaron Pomerantz: So it turns out a lot of birds are able to see UV. I don't know if all of them are, this is a good question. We could go ask someone over in the Museum of Vertebrate Zoology. But there are reptiles and birds that have evolved UV vision. Even birds can have ultraviolet patterns in their feathers. As humans, I feel like we're left out. We never got the UV vision. But many, many animals have evolved this ability to see UV.

Andrew Saintsing: Yeah, we are getting left out. It's a bummer.

Aaron Pomerantz: Yeah.

Andrew Saintsing: Other animals can see in infrared, ultraviolet.

Aaron Pomerantz: Yeah, we got stuck with the RGB color space, which is pretty lame.

Andrew Saintsing: Lame. Okay. So you study these questions from the perspective of the geneticists, right?

Aaron Pomerantz: That's right.

Andrew Saintsing: So what are you looking at? Are you looking at the genes that encode for these scale morphologies, scale colors, pigments?

Aaron Pomerantz: Yeah, that's exactly right. And again, people like physicists and mechanical engineers, they've looked at these structures for a long time. And the problem with that is you're steadying the final form. It's an adult butterfly, it might be a pin specimen and you're looking at this final product of a structure, whether it's a nano-structure or a scale formation. So the perspective that we try to understand in the Patel lab is what is the development of the structure in the first place? What are the pieces of DNA that encode for it? And then how does the structure actually form in an animal? And so it's sort of from this genetics and a developmental perspective that we try and understand where transparency, scale development and these nanostructures come from.

Andrew Saintsing: Oh, that's really interesting, especially because caterpillars, they have to go through metamorphosis to become butterflies. So you have to look at development through this stage when they're in the cocoon. That’s really complicated.

Aaron Pomerantz: It's challenging, right? So, we probably all at some point, at least maybe in a classroom, or for fun, raised a caterpillar or at least seen the process of metamorphosis. It's really incredible, right? You've got a caterpillar and it looks nothing like a butterfly, but it goes through this amazing metamorphosis process and it's during that time when a caterpillar turns into a pupa that it's building its wings and it's building those colors and structures. So we've done a bit of work really just watching what this process is like. It's hidden inside of the pupa, so we can't actually just watch it. And we've developed techniques in our lab that allow us to actually peer in and just create timelapses of this developmental process.

This is something that I was really interested in when I first came to the lab. You do a little bit of a surgical procedure on a caterpillar. So believe it or not, the wings of a butterfly are present even when it's in a caterpillar stage and it's called an imaginal disc. And so this ball of cells has all of the information to eventually become a wing. So what happens is we can basically take this little ball of cells out when it's a caterpillar then when it turns into a Pupa, it's missing a piece of its wing, but now it's developing properly and you can create a time lapse of the wing developing. So we've got these really cool videos that are online and I can share the link. You can watch the entire process unfold. Everything from the wing expands, scales develop, and then the colors come in like a flash, like a Polaroid picture developing just about 24 hours before it becomes a full butterfly.

Andrew Saintsing: Wow, that's really cool. I've heard that butterflies when, or in the process where the caterpillar is transforming in the cocoon that all the cells sort of dissociate.

Why is there a region on the caterpillar that will eventually become the wing if all of the cells just associate anyway?

Aaron Pomerantz: Yeah, I've heard that too. I think there's this idea that it turns kind of into soup and then reforms completely. And that's true to a certain extent. I mean there's a lot of change that has to happen in this body to get you from a caterpillar to butterfly, right? So it's undergoing a really, really amazing amount of developmental change. cells are breaking down, they're reforming, they're growing, but it doesn't completely turn into soup. There are some of these core cells that are tucked away even at the larval stage. And so there are imaginal discs, not only for wings, but for legs, antenae, many other parts of the body don't completely break down. And that's probably important. These are cells that are set aside, so it does undergo really, really amazing change, but not everything turns into soup.

Andrew Saintsing: I see. Okay. Do you change things in the genome of these butterflies? Do you actually make color changes happen? Change the transparency?

Aaron Pomerantz: Yeah, we do. It's a really cool time I think to be involved in this work, in part because molecular biology is changing very rapidly. When it comes to actually decoding and sequencing DNA, that process is getting at least cheaper and more affordable, it's becoming easier to do. So for instance, if you want to sequence the genome of an organism that's becoming more achievable. And then there's been advancements in gene editing technologies. So being here at Berkeley, I think most everyone has sort of CRISPR developed by a Jennifer Doudna's lab here. And that really is a game changer because now you can basically hone in on a segment of DNA in basically any organism and then just cut it. And what that will do is it will shut that gene off.

So now you can start to infer the function of genes of interest just by cutting it up with CRISPR Cas9 and seeing what that effect will be. And that's exactly what scientists are doing in the space of butterfly coloration whether it's through pigments or patterning genes, or in our case genes that might be involved in scale development we can just start to CRISPR these out and see what happens.

Andrew Saintsing: Have you found anything really cool, really interesting?

Aaron Pomerantz: Yeah. So, it was probably last year where I started out with some of these CRISPR experiments and I figured a good place to start would be just to control gene for patterning. And there was a postdoc in our lab a couple of years ago and his name is Arnaud Martin, and he's been really interested. When he was a PhD student and when he came to our lab was to investigate pattern formation in butterfly wings. So before colors come in and before scales even grow, there are certain genes that are laid down and they create a specific type of pattern. And a gene he was particularly interested in is a gene called Wnt.

And that will set up a certain pattern in the middle region of the wings. And when you knock that out, you just completely delete this wing pattern. And so that's one that I've used and it works really well and basically you get a perfectly normal butterfly, but it's just missing sort of a pattern. It's like you've taken an eraser and just sort of erased out a piece of the pattern on a butterfly wing.

Andrew Saintsing: Interesting. But it still has color on the wing?

Aaron Pomerantz: It will still have color in other parts of the wing, but this one, it just kind of looks like you took a whiteout and just completely eliminated it. And so that's a really powerful way to investigate gene patterns and colors because another gene is involved in pigmentation, it's called Yellow. And another lab at Cornell, the Reed Lab has been doing a lot of work doing CRISPR knockouts on pigmentation genes. So I would say this is sort of the trend where we're learning a bit more about how these pigmentations come in. But to be honest, we're really, really just scratching the surface of the structural coloration. We don't really know what genes are involved in creating a nanostructure or how a scale becomes a certain thickness to produce a certain wavelength. And that's the focus of our lab.

It's a bit more challenging because we know a lot about pigmentation genes, but we're really, really just starting to scratch the surface when it comes to scale development and nano-structure formation.

Andrew Saintsing: Yeah, that's, that's interesting to think about it that way. The genes have to be so tightly regulated because they have to be exactly the right size on the order of nanometers?

Aaron Pomerantz: Exactly.

Andrew Saintsing: Wow.

Aaron Pomerantz: So there's one butterfly that another graduate student in my lab, Rachel Thayer works on, and she works on a butterfly called a Buckeye. And that one can be either a brown in coloration or blue and coloration. And the difference between those two very distinct colors is just nanometers scale thickness in their scales. And so you can imagine just by finely tuning, you can be thicker or thinner and you can turn anywhere from like a gold color to a purple color just by finely tuning to a nano-scale level. So she's doing some cool experiments to try and pinpoint that. On my end, I'm trying to focus a little bit more on how scales form in the first place, because one might imagine if you can alter that pathway, you might eliminate a scale and then maybe you can become one of these transparent butterflies.

Andrew Saintsing: That's really cool.

Aaron Pomerantz: Yeah.

Andrew Saintsing: This is your reminder that you're listening to The Graduates. I'm Andrew Saintsing, and I'm speaking today with Aaron Pomerantz. So you mentioned a little while ago about how it's become ways easier to study genetics, right? And actually you've been using the new technology in genetics to kind of go out into the field and study things outside of a lab, right?

Aaron Pomerantz: Yeah, exactly. Before I started my PhD here, I was actually conducting fieldwork in Peru in a place called the Tambopata Research Center. And this is in the Amazon rain forest. It's a really, really beautiful forest. It was kind of in between Grad School for me. I had finished a masters degree at the University of Florida and I didn't know exactly what I wanted to do with my life, but I joined a friend on a trip to Peru and that actually turned into a job opportunity. They sort of invited me to come back and be a field biologist. So I did that. I made several trips to the Amazon rainforest and it was a blast. I mean, just walking around trying to find... I mean, to me it felt like playing Darwin, I was just wandering around rainforest, trying to take pictures, describe life histories of organisms that I had never seen before. And it was a really incredible experience.

And it was during my time working out there that I realized the challenges that are associated with doing this type of field work. So for instance, it's hard to take equipment out into the field with you. And the rainforest, as the name applies, rains a lot, so this can ruin electronic gear. All of these things make it challenging to actually conduct scientific research. So I sort of stumbled on a portable microscope, and this is what I was looking at because our facility out there had a microscope that had been eaten alive by fungi. But I was looking for some sort of alternatives to portable tech like this. So I found the Foldscope and this was developed by a researchers at Manu Prakash's lab at Stanford University. And what it is, it's an origami paper microscope. You just sort of assemble it, you put a lens in there, and then you've got a $1 microscope.

Yeah, it was really cool. And so I took it out to the field and I used it and this got me really excited about what else can become cheaper and more portable in the realm of science. And then how could this impact field work as well as science education? Because I think if you have cheap portable tools, then it becomes more accessible to people outside of big universities like this. At the time I had also stumbled on this early access program from a company called Oxford

Nanopore Technologies. And they had developed the first ever handheld DNA sequencer.

Andrew Saintsing: How does a handheld DNA sequencer work?

Aaron Pomerantz: Yeah, it's really interesting. So this company developed this and it works with what's called Nanopore Technology, and a Nanopore, if you think about it, it's just a super, super, super tiny hole. And it's so tiny that one strand of DNA can slip through. And how it works is there's an electric current running through where these nanopores are embedded in a membrane. And then as DNA goes through, there's a change in the ionic current that's passing through. This is important because if you think about what DNA is, it's composed of four nucleotides, A, T, G and C. Each one of those chemical compounds gives off a slightly different electrical output when it passes through the nanopore. So just by measuring a change in current as it passes through, you can tell which base it is. An A passed through it, and then a C, and then a T and so on. And this is how you can rapidly sequence or decode DNA.

Andrew Saintsing: Wow. So a strand of DNA is passing through a hole and you're measuring as each individual base goes through the change in current?

Aaron Pomerantz: Exactly.

Andrew Saintsing: That's incredible.

Aaron Pomerantz: It's really cool. And this also allows it to be very portable for those not super familiar with DNA sequencing technologies. There are a few sequencers out there that primarily use like Sanger sequencing, Illumina sequencing, PacBio sequencing. These are all different types of platforms that different companies have developed, but they're all pretty massive, like the size of a refrigerator, let's say. But this portable sequencer, it's smaller than a cell phone these days. I mean our cell phones are getting pretty big. I'd say it's more like a Kit Kat bar almost.

Andrew Saintsing: Wow.

Aaron Pomerantz: So it's pretty tiny and it plugs into your laptop. And so really you can put your DNA sample, run it on your laptop and this allows it to be portable. And so I've even taken it out to the Amazon rainforest several times now where we've done real time DNA sequencing out in a jungle.

Andrew Saintsing: So, you see an animal that you're interested in, you maybe take a blood sample and just kind of stick a drop of blood in this device?

Aaron Pomerantz: Yeah, more or less. So it sort of depends what kind of question, what type of DNA or even RNA you want to sequence. If let's say you just gave me a cheek swab right now or a blood sample, we could extract the DNA from that and then you could run that DNA on the sequencer. And since it's all of your DNA molecules, it would basically be coverage of your entire genome. But let's say we weren't trying to get your entire genome because it's really big, and it's expensive, and it's a difficult thing to do. We might just want to copy one of your genes and then use that to identify you, let's say, so this is what's called a DNA bar coding. You basically just look for a specific gene that you're interested in sequencing and that's what you can put on the sequencer.

So this could allow you to do things like, if you're just interested in identifying species or maybe let's say a pathogen or this bacteria or a virus, you can use PCR polymerase chain reaction and this allows you to copy just one piece of DNA. And so this allows you to pull lots and lots of samples and then you can run all of that on one of the sequencer.

Andrew Saintsing: Are you doing PCRs out in the jungle too?

Aaron Pomerantz: Primarily, yeah, that's been one of the goals is to do this really rapid DNA bar coding. And so when I was working at the rainforest, I realized even as an entomologist, it's very hard to identify things. You can look at the morphology of an organism, but unless you're an expert in that specific group, it can be really hard to identify things. But you can use DNA to identify things. It's in a lot of ways more powerful and it gives you a more concrete answer. And if you want to identify new species, this is sort of common practice these days is to include genetic information. And especially if it's during an outbreak, let's say. So researchers have used the same type of technology to go out during outbreaks, whether it was the Ebola outbreak from 2014, 2015 or recently the Zika outbreak in Brazil. So if people are getting sick and you want to identify what pathogen it is, you can use this same technique.

Andrew Saintsing: That's really cool. So you mentioned at the start of this discussion about DNA bar coding, that this is great for science education. So actually you've already used this technology in a class?

Aaron Pomerantz: Yeah, we had our first ever class this past summer where we tried to apply this. And I've used this in Ecuador. We had some funding through the National Geographic Society to test this out early on, two summers ago. And I've taken it back out to Peru to do a bit of testing, but we had never done it with students. And to me this seemed like a really cool application because I think, at least for me, when I was in school, I wasn't really that into genetics. I thought it was like pretty boring to be honest. And maybe that's because I had only sat in classes and listen to someone lecture about it. And it wasn't until I started to get my hands on these actual tools in a lab as an undergraduate and then into Grad school that I really got interested.

And to me, I think hands-on is the best way of learning, not just for myself but for a lot of people. So that's why I'm really interested in this because I think when students can get their hands on this stuff, they can realize it's not that complicated. Anyone can extract DNA, anyone can do these molecular experiments and now anyone can sequence DNA. And that was the whole goal, and do it out in the jungle. So that's exactly what we did. This was through an organization called Field Projects International. And they're a nonprofit. It was set up by a couple of graduate students and they just run field courses. And the only difference is we had sort of a classical field biology course and then we brought some of these tools down to run what we call the genomics in the jungle course.

Andrew Saintsing: So how did the course go?

Aaron Pomerantz: It was awesome. To be honest, I didn't really know what to expect. I didn't know who was going to register. It was open to anyone, it didn't have to be a student or a certain age group or anything, but we had all sorts of different students register for this course. Some were in their first year of Grad schools, some were postdocs, some were undergraduates, some weren't even students at all. To me that was cool to get a mixture of people together with different backgrounds. Some were local Peruvian students and that to me was a great experience because we could split them up into teams of people who are maybe a little bit more advanced in molecular techniques to people who had never picked up like a pipette before. In the end it was successful I would say, because we were able to go through all of the steps involved with these molecular experiments and we were able to sequence it and get our answers in real time.

Andrew Saintsing: So had you set up labs like, you wanted to answer this question that you had already come up with or did you say, "Hey, we're out in the jungle, you guys can go answer whatever question you want?"

Aaron Pomerantz: Yeah, that's a good question. It was a bit of both. So some of these specimens we had already collected like, butterflies in their host plants from a nearby researcher, some were from Heller monkeys and we wanted to look at their microbiome, their bacteria makeup from different populations. And then some of them they could just go out into the field and collect. And so it was a mixture of sort of open questions and to me that was really exciting because it's the Amazon rainforest. There's tons of things that are unknown. And so the first portion of the course was actually just hiking through the jungle, I'm doing fieldwork, collecting samples, and then learning how to process those. You have to extract the DNA. Maybe you're doing PCR and then you have to prepare it to run on that nanopore sequencer.

Andrew Saintsing: So did anyone find anything that no one had known before in this class or was it anyone make any new discoveries?

Aaron Pomerantz: Yeah, I think so. One of the challenges when you are trying to know if you have, let's say a new species is it takes a lot of work. Sometimes it's hard to just sequence something and say, "Oh yes, this is for sure new." I think there are probably things that were sequenced, and I'll give you one example of something that I think was really interesting. One of the course instructors had been catching bats out in the rainforest and the bats are really hard to identify. So that was very helpful to use DNA to identify these bats. But even cooler, I think as we looked at the parasites living on the bats, so these are called ecto parasites. Anything from like ticks to fleas to a weird type of fly that lives on bats. It's in a family called Nycteribiidae.

And they look super weird. If you get a chance to Google that. They're really, really weird looking flies that live on bats. But some of these could very well be undescribed. It's the Amazon rainforest and these are really odd arthropod critters that are very diverse. So those were some of the ones that sequenced and we got back data. So I think overall this will eventually go into potentially new descriptions.

Andrew Saintsing: So you think as you continue this class, you'll be able to like kind of merge your science education with your own research and maybe get papers for yourself out of it?

Aaron Pomerantz: Yeah, for sure. I mean, it's been a fun process. I started this passion before I started Grad School. So it's been kind of interesting to seeing if I can integrate things, make it part of a coherent thesis. But in any case, it's just been really rewarding for me as a graduate student to do these new courses, test out this new technology, work with the companies a bit. So to me that's a really rewarding experience paper or not. I think, in the future we we're already planning another course next year. Some of those course instructors are going to try and do one in India. I would love to do some of these more locally, like at UC Berkeley too. So I think there's a lot of potential and a lot of interest because the barrier to entry is not that high and I think it's a really rewarding experience.

Andrew Saintsing: Yeah, it's a great time to be in science, especially for a non-scientist or for people who haven't formally been trained as scientists. There's all these opportunities to get involved in data collection and all this stuff.

Aaron Pomerantz: Exactly. Yeah, citizens, scientists, ways to communicate, ways to gather data or work with scientists. There are definitely more opportunities than at least, maybe when when we were younger. I mean, when I was in high school I don't think there was anything quite like this. And this is in part due to developments in technology which have really just come about in the last few years. So I'm excited to see where it keeps going. I hope the price continues to drop and just become more accessible for learning opportunities.

Andrew Saintsing: Wow, that's really great. So are you interested in continuing on as a science educator researcher? Are you interested in being a professor at a university?

Aaron Pomerantz: I would love to do something that enables the ability to do scientific research and do science education. So I don't know exactly if that's going to be 100% academic path or appointment, those are hard to get no matter what. And that's a tough gig to get these days. I like museums. I like the Cal Academy of Sciences because I think that's a cool mixture between science outreach and doing research. But yeah, I'll just have to keep working and see what kind of opportunities open up. I mean, in part working with biotech companies is really interesting to me too because they're developing these new tools. A lot of them have an interest in this type of outreach work. So I'm trying to keep my options open and do the best I can as a scientist and keep up with science outreach as well.

Andrew Saintsing: Cool. So we're reaching the end of the program. Are there any thoughts you'd like to leave the audience with? Anything at all?

Aaron Pomerantz: Yeah, I mean, if you're listening and you found any of this school, whether it's structural coloration or portable sequencing technologies, feel free to get in touch. I'll be here at UC Berkeley for the next year and then move out to the marine biological laboratory, which is in Woods Hole, Massachusetts, where my advisor has just become the new director, Nipam Patel. There are lots of cool opportunities, but feel free to get in touch. And especially if you're interested in these types of courses too I would love to hear. So you can follow me on Twitter, I'm @AaronPomerantz. On Instagram, it's @nextgenscientist. So I love doing social media outreach, and I'd love to be in touch.

Andrew Saintsing: Today I've been speaking with Aaron Pomerantz. We talked about how he has been studying structural color in butterflies and transparency and moths. And then we talked a little bit about his experience getting more involved in science outreach and science education. There's a lot of cool technology out there and it's a great time for everyone, not just formally trained scientists to get involved with science. Thank you so much for being on the show today Aaron.

Aaron Pomerantz: Yeah, thanks a bunch, Andrew.

Andrew Saintsing: Tune in two weeks for the next episode of The Graduates.