

Planariology with Oné Pagán

Ologies Podcast

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Oh, hey. It's that second hole that you have to carve into a can of pineapple juice in order to get the first one to glub out, Alie Ward, back with an episode of *Ologies* you better not sleep on. You are about to get walloped with excitement, and passion, and gossip about drugs, and donges, and aliens, and how it all relates to these tiny, goofy, dick-shaped flatworms. You know what you're gonna do tomorrow? Tomorrow, you're gonna paint an airbrushed mural on the hood of your car that just says, "I goddamn love planarians."

But before we get you there, let's thank the folks at [Patreon.com/Ologies](https://www.patreon.com/Ologies). They send in as little as 25 cents an episode and they get to ask questions. Thanks also to everyone who is sending this episode to friends and family, despite the fact that it is about worms and it is not safe for work. Thanks to everyone who rates, and subscribes, and of course reviews. You know I pick a new one each week to read. And this week, *obsesedwithscience06* says:

Oh hey, I hate all podcasts, but this one, it is amazing! Thank you Alie! I hope ya read this!

Obsesedwithscience06, I did read it. Also, happy birthday.

Okay, let's get into it. Planariology, it's indeed a thing. It's the study of planarians, which are a class of free-livin', free wheelin' flatworms. And the word *Planaria* comes from the Latin for 'on level ground', because these things look like if you miniaturized a human penis and cranked it through the rollers of a pasta machine. Flat, phallic, little triangle-shaped head that contains tiny brains to boot! This ologist has studied them for years, and we met via Twitter, and he is a gem.

He is an Associate Professor of Biology at West Chester University in Pennsylvania, and author of the popular science book, *The First Brain: The Neuroscience of Planarians*. He also wrote *Strange Survivors: How Organisms Attack and Defend in the Game of Life*, and he's working on a new book about drunk dolphins - no joke - due out next year. He got his bachelor's degree in general sciences and his master's in biochem before heading to Cornell for his PhD.

And we talk about what makes a brain, the personalities of clones, the sexiest underwater Olympic sport, limb regeneration, and how these simple little creatures are helping solve medical mysteries; with your new favorite planariologist, Dr. Oné Pagán.

Oné: I'm actually going fanboy with this. I've heard about your podcast for a long time and it's really cool.

Alie: When you tweeted at me, I was like, "A whole episode on planaria? That's amazing! I want to do that!" Now, how long have you been studying planariology, if you will?

Oné: Okay. So I have a confession to make, right off the start. I am an accidental planariologist, as it were. I've never taken a zoology course. My training is mainly biochemistry, and pharmacology, and neurobiology. And I came to planarians by, I don't know, I like to call it fate,

if you will. First of all, I was a nontraditional student. I went back to school at 35 for my PhD. So, I did my bachelor's work for several years. I got married and started having kids... Well, my wife helped, of course. [*female voice: "You're welcome!"*] Then I did my master's, working full time, and I was very fortunate to have very good supervisors. I always wanted to do the PhD, but I needed to work. I had a family.

So when I was 35, a person who ended up being my PhD advisor came to Puerto Rico. I'm Puerto Rican, by the way. I was born and raised in Puerto Rico, and I did all my education up until the master's there. A collaborator from my advisors in Puerto Rico came to visit and everything, and he just happened to recruit students for Cornell University. So he actively tried to recruit me, I applied, they accepted me, I got a fellowship and, well, I packed my family and I went,

Alie: Oh my gosh! Wow!

Aside: Before becoming a professor at West Chester University, Oné got his PhD in pharmacology from Cornell University, studying in a biochemistry lab with the brilliant Dr. George Harris, a chemist.

Oné: At the time I was studying the dopamine transporter and its relationship to cocaine, the abuse drug. I saw a paper from a researcher at Temple University about how planarians' guts showed addiction to cocaine.

Alie: What?

Oné: Yeah.

Alie: Cokehead planarians!?

Oné: Yes, cokehead planarians. And later on we learned that we can do that with nicotine, methamphetamines, and whatever. So it's really fun. Well, for them. [*"I'll have what she's having."*]

I knew about planarians, but very peripherally. I knew that you cut their heads off, they will grow it back and whatnot. So I got very excited, and I went to my advisor and I went, "George, guess what? We can do these experiments in planarians!" But of course, he was a physical chemist. Something slimy? An animal? He essentially said No. He said something in the lines of, "Well, when you have your own lab, you can do it." And that's precisely what I did.

Alie: Oh my gosh. And how long have you been studying them now?

Oné: Well, it's been almost 15 years now. I started at West Chester University in Pennsylvania in 2005. They foster research and that's the best of both worlds. I love teaching because... if we think about it in the same way, I get paid to read about what I like, to talk about what I like, and the students have to listen to me. So it's awesome.

Aside: His students, according to internet chatter, love this dude. Now, okay, he was working on his PhD and needed a model for research that was relatively cheap. And he was running some controls and found that a compound he used in the controls actually changed the planarian behavior. And he calls this wormy event a 'serendipitous observation'.

Oné: So, as any half-decent scientist does, I ran my controls with just the MSO and something weird happened to the behaviors of the planarian. [*“So weird.”*] And the first paper of the lab was about the effect of the MSO in planarians.

Alie: And going back a step or two, what is a planarian? I know it is a flatworm, but can you describe it for someone who's maybe never seen one? How big are they? Where do they live?

Oné: Oh, well it depends on the type of planarian. So ‘planarian’ literally means flatworm, but they describe a wide variety of species. There are marine versions. They're called polyclads, and they are some of the most beautiful worms in the sea. The ones that I work with are freshwater planarians and many of those species possess a very interesting property. They are the ones that you can cut their heads off. They will regrow any part of their bodies, including their brain, in the right way.

Alie: How are they even doing that?

Oné: Oh, well if you figure it out, you'll get a Nobel Prize, and I hope you mention me in your speech.

Alie: Fair enough.

Oné: I think you've noticed that I'm very enthusiastic about what I do.

Alie: I love it. Let's say that you wanted to look for a planaria. Where is a good place to look? Are they in puddles? Are they under rocks? Do you need a microscope?

Oné: Nope. No. It depends on the species. The typical ones, they're about maybe an inch long, a couple of centimeters long. Every planarian is actually a carnivore. They're predators, so they even eat each other happily. They're cannibals, even. So a very good way to hunt for them, as it were: you get a little container, you poke holes in the lid, put a piece of meat inside of it, and leave it in the water. And within a short period of time, there's going to be a bunch of stuff, including planaria. But the ones that I work with, they're available commercially. I can buy them.

Alie: And that's for lab use, right?

Oné: Yes, and they are used in many schools for demonstration experiments and activities like that. I just throw drugs at them [*laughs*] and see what happens.

Alie: [*laughing*] Oh my god. And now, what kind of brains do they have? You mentioned they can even regrow their brains. And obviously if they're reacting to chemicals and drugs, they have a nervous system. What's their anatomy like?

Oné: They have relatively sophisticated brains for a very small invertebrate, and they are capable of learning. They have many of the same neurotransmitters that we have. And probably one of the most interesting anatomical characteristics of planarians is that they have what is called a bilobar brain. Just pretty much like us. Well, not exactly like us, but you know what I mean. With two lobes joined together. And instead of having a single spinal cord, they have two, one per each lobe, and those spinal cords are connected by nerve fibers. They're really cool. They're really, really cool.

Alie: Wow. And now if you, let's say, were to injure a planaria, if a planaria were to get bisected, does it matter where they're cut and they can regenerate?

Oné: You can cut it in any way you want, but that's a very good question because there's a part of the planarian that does not regenerate. And you're going to love this one. Planarians eat via the same orifice where they defecate. [*Alie low and distorted: "Nooooo!"*] Yes, they do. Yes, they do. And they extend a tube called the proboscis and that's how they eat. Like an alien in a movie. Okay. [*slurp*] They stick it in the prey and they suck it dry. [*Alie, glitched: "Oh my god!"*] And I've seen that in my laboratory. They wrap themselves around water fleas, Daphnia, like a snake, and they do that. You can cut almost every part of the anatomy of the planarian except the proboscis. That part does not regenerate.

Aside: When I hear proboscis, I think mouth area. I think a nose hose. But I looked this up, and in a planaria it's on the belly near the back end, kind of like if you had a pool noodle coming out of your navel, but you could shit out of it, and then five minutes later you could use it to slurp up the body of your uncle like he was a Frappuccino.

Now, a lot of freshwater planarians are a mottled, peachy brown, but fluttering marine ones can be gorgeously, brightly colored to advertise that they'll poison the hell out of their enemies. Planarians breathe through their skin, and they don't have a circulatory system so their gut kind of acts like a New York subway map to deliver their nutrients. And of course, they have the nubbins of an early brain. All of these parts are under one of the best warranties in the business. Oné continues:

Oné: You can take a piece of the tail, a piece of the head, laterally, whatever, and they regenerate. They need a minimum of about 10,000 cells to regenerate. That's about, maybe... I think it's 0.08 cubic millimeters or something like that.

Alie: And do they ever do work on the DNA to find out if it's the same DNA on both halves or does it change at all?

Oné: Well, absolutely. There's a couple of planarian species which have been sequenced. They have their own genome projects. The ones that are used commercially, they are beginning to be sequenced a little bit. But one curious characteristic of any flatworm is that they don't have the exact genetic code as everything else.

Aside: Apparently, there is something called 'the alternative flatworm mitochondrial code' that encodes for different amino acids than most other creatures. Is this a glitch in the simulation? Are they aliens?

Oné: Nobody knows why, but it's a rather interesting mystery.

Alie: Yes! And now, how are they responding to different chemicals and drugs that you're administering them?

Oné: All right, so the beauty of those is that they also display sophisticated behaviors. They are very sensitive to their environment. Of course, if you're small, if you're a centimeter long; [*"You're so little."*] you're small, you're not venomous, you cannot fly, you're not fast, what do you do? You hide. So for that reason, they tend to shy away from the light. They go to the proverbial

dark side. They like to hide. You can actually use that to your advantage in behavioral experiments. Also, you can actually measure their gliding velocity because they glide at the bottom of a Petri dish or any type of container like that, and they can glide with certain speeds. Many compounds, they actually decrease their velocity.

Aside: Okay, I looked into this, and planaria can glide by beating little cilia projections in a layer of... mucus. And kind of like a cop on New Year's Eve, observing locomotion can say a lot about how loaded they are.

Oné: Another type of response is a seizure-like response, meaning that, for example, if you give them a certain compound in relatively toxic amounts, they go into what, for all intents and purposes, are seizure-like movements. And you can quantify those. We use all of those techniques in my laboratory.

Alie: Is there one substance in particular that surprise you, how they reacted?

Oné: Well, one would not expect to observe such an anthropomorphizing property as addiction, but planarians can get addicted to substances. If you give them nicotine or cocaine, for instance, or even sugar, and you allow that substance to soak in the water for a while, then you take the substance away, they go into something very much like withdrawal. They get the shakes. They start swimming around like crazy. They bob their heads back and forth. And you can quantify that. You can train those planarians to respond classically to substances that are abused by people. They display surprisingly similar behaviors as if they were addicted. It's a beautiful model for that.

Alie: How many different experiments do you have going on at once? What is a typical day in the life of a planariologist?

Oné: Well, you've got to have your students help you out. And that's something that I wanted to say right off the bat, a shout out to all my students. I've had many over the years. Right now I have to close the lab because of the worldwide reality that we are living in, and I miss them terribly. Hello to all the Pagán Lab, whenever you listen to this.

We try, of course, to run the appropriate controls and to plan ahead very well the experiments that we do. Once we obtain the data, the fun begins [*DJ airhorn*] because we can actually analyze it. We can generate graphs. We can do all those types of things. Then, if we get a baseline of the effects that nicotine does to planarians, for example, we can actually screen substances that may counteract those effects. That's what we've done with substances like cocaine, nicotine, and some others.

Alie: I'm curious too if that makes you consider any of your own behaviors in your own life. Like, do you ever see how planarians react to sugar and decide you need to cut back on donuts?
[laughs]

Oné: Oh, well I'm addicted to a certain type of beverage that is served in a coffee shop that rhymes with 'bucks', so I can relate to that. But planarians, again, they cannot use a straw, but they react in ways that will allow us to figure out, "Well this planarian is certainly uncomfortable in the absence of a certain chemical stimulus." Once we quantify that, we can see the difference that it makes by adding, I don't know, a proverbial antidote.

Aside: Oné says that the aim of the lab isn't to study addiction, per se, but to figure out a way to counteract the toxicity of things like nicotine, or cocaine. So, working with these worms, a simpler model than a lot of labs, is saving lives. Now, for more on addiction, listen to the Molecular Neurobiology episode with Dr. Crystal Dilworth, or Addictionology with Erin Parisi.

Oné: Because addiction is a very complex phenomenon. We can get addicted to anything, not only chemicals or food, but gambling, things like that. So, it's much more complex. But, we can study toxicity, and the toxicity of such substances, using planarians. We can actually use terms like addiction and withdrawal with an asterisk, as it were, because it's very anthropomorphic. We don't know what a planarian thinks or how it feels. By the way, did you know... This is something that I learned literally about a week ago: Science Twitter is amazing, because I got a very interesting paper from a colleague in Australia who I met from Twitter. Her name is Shauni Omond from Trobe University in Australia, and she studies sleep in planarians.

Aside: So, Dr. Shauni Omond's team discovered that planarians do sleep! Now, the study's conclusions read, "Despite simplicity, inactive flatworms appeared to be sleeping, specifically quiescence was organized in a circadian manner, occurring largely during the daytime."

So, do not invite a planarian to lunch. They will oversleep. They will text, "On my way," before they've even left the house, and your party will not be seated until they arrive.

Remember brunch? I don't.

Oné: So, I want to thank her for sending me a paper that I'm geeking all the way about because I didn't know that planarians sleep. Recently, I heard your episode about chronobiology and circadian rhythms and everything, so you know about the suprachiasmatic nuclei and all these types of things. I'm pretty sure planarians have something like that. But we don't know!

Anyway, I want to thank Shauni for the paper. I'm reading it and enjoying it. That's the beauty of it. I'm telling you, I'm 55 and I feel like a kid learning all these types of things.

Aside: The science hero you didn't know you needed! Now, from a pharmacological perspective, he's able to use simpler animal models, these flatworms, rather than higher vertebrates. But for what kind of stuff?

Alie: And what about using planarians in terms of addiction or substance abuse with opiate issues that are, kind of, plaguing a lot of the world? Is that applicable to them as well?

Oné: Yes, absolutely, because they have similar receptors to opiates to the ones that we have. Other groups, particularly at Temple University, Dr. Bob Raffa, Dr. Scott Rawls, they're working on that. The thing is that planarians were traditionally used in regeneration and developmental biology, but it was only relatively recently that they have been, kind of, popular as an animal model in pharmacology. I'm very happy to say that we're one of the few groups that do that, but it's gaining popularity. It makes sense. It's applicable to many areas, and to have such a simple yet powerful model, it's really cool. There's no other way to say it.

Aside: Let's just beep beep... back this up a little to his history.

Alie: Now, you were interested, not necessarily in planarians growing up, but were you interested in how the brain works? What triggered that in you?

Oné: Well, there was never any doubt whatsoever that I was going to end up in science. I can give you an example. When I was about four or five years old, I don't remember this, but my mom told me that I asked her whether God invented microscopes. That was my question at five years old, just to give you that, that idea. So, I went to college and actually my bachelor's is in general science in part because I couldn't commit. I liked everything. I took biochemistry, I took astronomy, I took genetics. I never took zoology, as I told you, but what can I say? Science is magnificent.

Alie: What about your book, *The First Brain: The Neuroscience of Planarians*, why is it called the first brain?

Oné: Okay, so that's another funny story because when I decided to think about writing a book, it was going to be about planarians and everything. And I liked the brain and everything, but I thought about a horrendous title at first.

Alie: Oh no.

Oné: You want to hear what it was?

Alie: Yes!

Oné: The Neuronal Worm. *[laughs]*

Alie: *[laughs]*

Aside: "The Neuronal Werrrrm." Catchy, sexy titles like that just fly off the shelves, but nevertheless he took the suggestion of an esteemed colleague, Dr. Bob Raffa, and went with the title: *The First Brain*. Phylogenetically, Oné says, the planarian evolved to do its thing before the line that led to vertebrates shot off. But they have cerebral ganglia, a bi-lobed glob of nerve tissue and two lateral nerves that are connected along the body by transverse nerves, kinda like having a full body tattoo of a ladder, but inside, and made of nerves, making them a good simple model for the human brain. Oné discusses pain response later, which may ease your mind in terms of their use in medical labs.

On the topics of gathering the nerve to use your brain, how about a little pep talk?

Oné: My philosophy in life is that if I don't ask for something, there is zero percent chance of getting it. So, I don't have an agent. I never had an agent. I still don't. But I did my research, I wrote up a proposal, I sent it to a few publishers like, "I don't have an agent, but this is my preparation. Here's my CV. Would you consider this book?" And some publishers will say "Thank you, no thank you." But a rather obscure publisher called Oxford University Press said yes, and the rest is history.

Alie: What was it like the day that you found out that your book was getting picked up?

Oné: Oh my God. It was like, I read the email and I said something that I shouldn't say in a podcast, but it starts with Holy something.

[clip from The Good Place: Eleanor Shellstrop, "Holy forking shirt!"]

Those were my first words. That's what I said, and I said it out loud, and thank God I was alone. As soon as I got that I called my wife... You have to understand, Alie, I've always been a

bookworm, that comes with the territory of the things that I do. I love books. And I realized that for the first time I was going to be on the proverbial other side of the fence. People would read me - aside from scientific papers because of course I wrote a master's thesis, I wrote a PhD dissertation. But nobody, you know, unless it's really interesting, read those. But a book will be read by many. And I felt incredibly... after I calmed down, I felt humbled. I felt incredibly happy and proud. I was geeking out.

Alie: That's so exciting! That's so inspiring.

Oné: Thank you.

Alie: Can I ask you Patreon questions?

Oné: Absolutely. Ask away! Do you remember Captain America in the movies?

Alie: Yes.

Oné: Okay. So you'll remember this quote, "I can do this all day."

Alie: [laughs]

Aside: But before we get to your question, as you may know, each week we toss some cash at an organization chosen by the ologist, and this week Dr. Oné Pagán asked it to go to NoKidHungry.org.

22 million children rely on the meals they receive at school, and for some it's the only food they'll receive in a given day. NoKidHungry.org works with federal and local governments to support kiddos in need. They give emergency grants to food banks. They make sure that resources go to the most hard-hit areas. And despite school closures and pandemics, they work to make sure every kid gets three meals a day. A donation is going to NoKidHungry.org, and that donation is made possible by Patrons of the show and sponsors who you may hear about now.

[Ad Break]

Okay, back to your questions.

Michelle Krebs, Bennett Gerber, and Jesse Markowitz all had the same nagging curiosity:

Alie: A lot of people had this very great question. Why are they so popular for school dissections and where are the schools getting them?

Oné: Well, the school can get them from suppliers, commercial suppliers. And I know that there's some schools that actually go, for example, to ponds and they actually catch their own.

Alie: Oh!

Oné: They are so easy to use because you don't need any special equipment to store them. You don't need an incubator and you can actually put them in a container in a cupboard. As long as you don't put them in direct sunlight, they'll live. You can feed them liver and they will thrive. And again, you don't need any specialized equipment. You may need a stereoscope and a microscope to actually look at them. Nothing specialized.

And they're so cute, particularly the freshwater planarians, the ones that have only two eyes. There's some that have multiple eyes, by the way. But the ones that have only two eyes, they are always cross-eyed. Nobody knows why. So they're really cute. Nobody really knows the physiological relevance of that.

Aside: Patron Joe Porfido asked: But *why* are they so cute? I mean, planarians do look like your most stoned friend pissed off a wizard and got turned into a very, very small penis. They look like a chubby arrow with eyes. Like if a snake got a branding makeover from Hello Kitty. It's bananas. They also look like a banana! Patron Haile Hullings said: No question. I just think they are very, very cute; and I agree.

Now from cute, to cut. A lot of you had a similar question about their science-fiction-level ability to move on from physical trauma, like a Terminator, only a Worminator. Eric Girard, Erin Unson, Rachel, Ross Owen Qualls, John Sansone, let's get into it. Along with:

Alie: Patron Nadine Duke on that note says: What if you cut them in half lengthwise? If they are only halfway cut, do they then develop two heads?

Oné: They will be developing two heads. Actually I've seen experiments... Planarians have been very popular for decades in Japan, of all places.

Alie: Really?

Oné: Yeah. And I've seen many books and actually I can send you pictures of the books that I have where they keep cutting them and you can actually make them grow like seven, eight, 10 heads. It's kind of a little bit of a hobby.

Alie: Oh my god.

Oné: Oh, yeah. They're Fantastic!

Aside: How is this even happening? Stem cells. Specifically ones that are pluripotent, meaning they can make any type of cell needed. In humans, only our embryonic and germ cells in the old gonads can do that. And if researchers can learn more about these types of stem cells in planarians, it might mean better therapies in other animals.

Patron Michelle Jacobs asked this very grammatically on-point question: Into how many segments can you cut one at a time? Michelle, I looked this up, and a planarian can regrow its whole damn body out of only a 1/279th of itself. That's like getting your hand lopped off and it grows a whole new you from it. In a matter of about three weeks. I have laundry older than that! But Oné told me a few fellow planariologists in Japan and Spain discovered a specific gene in these pluripotent cells and it's called *nou-darake*.

Oné: Which in Japanese means 'brains everywhere'.

Alie: Wow.

Oné: When you express those genes in a weird place in the planarian, they generate brain tissue. There's so much that we don't know, which makes it so incredibly, freakingly interesting.

Alie: Do you think that when they are cut, do you think that they experience pain? Do they recoil like it? Or have they evolved so much to be able to do that, that it's not detrimental to them?

Oné: Well, that's an excellent question because they certainly have the receptors that we usually relate to pain, okay? But it's very difficult to ascertain that. I know that, for example, any type of stimulus in the water, they get scrunched, they recoil away from the stimulus, which serves them well because if somebody tries to touch them, it will likely try to eat them and it serves them well to recoil from that.

Aside: Remember, they are tiny flat, delicious, flaccid slimy things and the best defense they have is just looking adorable.

Oné: As far as pain is concerned, I don't know. But I can tell you something. I can cut the planarian head, and the head by itself will keep, you know, gliding very happily on the surface of the Petri dish with no indication that they're suffering or anything like that. I have videos of that.

Alie: Oh my gosh.

Oné: Yeah. The rest of the body kind of doesn't know what to do.

Aside: When Oné says gliding, by the by, he means it. They move through water like figure skaters on a victory lap. Only they're very small ribbons of flesh. Travis DeMello asked: Is their ability to regenerate biologically similar to plants' ability to grow from cuttings?

Oné: That's a very good question. That's a very good question. Which generally means that I don't know the answer to. *[laughs]* However, there's many scientists who are trying to come up with common ground or biochemical pathways between plants and animals. There's a whole very controversial field about plant neurobiology. That's yet another story that will be the topic of, like, 10 podcasts for later on. But the point is that yes, plants do regenerate and whether they followed the same specific biochemical pathways is an interesting question, but we don't know that yet. You have the best listeners, by the way.

Alie: Don't I! Aren't they the best?

Oné: They are the best. Say hello to everyone. Well, I can say hello by myself. Hello everyone! You are the best listeners ever! *[happy cheers]*

Alie: Mike Monikowski, who always asks great questions, says: Where do they come from originally and how big can they get?

Oné: Well, it depends on the species. The record of a freshwater planarian, I think it's about 60 inches long, but they're not very common. I may be a little mistaken, but they can get really big, the freshwater ones.

Aside: Somewhere on earth there is a five-foot-long phallus-shaped flatworm. There are also giant 12-inch land-dwelling ones, called bipalium, that look like a worm whose head is shaped like a medieval battle axe. Somewhere, right now, there's one eating with its anus, living its best life, not even knowing we're talking about its slimy majesty. They don't care.

Oné: They are distributed worldwide. In every single habitat that they can get, except Antarctica, you will find planarians. There's actually a planarian that was named after Puerto Rico, my birthplace.

Aside: I looked this up and there are several genera of flatworms named after Puerto Rican resident, zoologist and legendary planariologist Dr. Roman Kenk and his daughter Dr. Vida Kenk, herself a biologist. Some of these Kenkia worms can be found in caves and deep lakes. They hangout wherever - unlike your cousin's second wife, they don't need somewhere fancy.

Oné: I mean they're found everywhere. You know, I love science fiction too. And if you remember your *Jurassic Park*, "Life finds a way," and planarians are a premier example of that.

[clip from *Jurassic Park: Ian Malcolm*, "Uh, well, there it is."]

Aside: Rob Sheppard, a patron wrote in and said: I first learned about flatworms in a science museum when I was a kid. I've always wanted to see them in the wild, with appropriate magnification of course. But I don't know where to look to be most likely to find them. Where would I look?

Alie: I wanted to ask about experiments. A lot of people are home, maybe with kids - is there kind of a fun science observation, or planarian hunting that you maybe could do if you wanted to do a science lesson at home?

Oné: Absolutely! They're so easy to maintain. You can do, for example, the preference between dark and light. You can get a circular Petri dish, cover half of it with electrical tape and you can actually count over a period of 5-10 minutes, how many seconds do they spend in the light and in the dark.

That's some of the experiments we're doing in the lab to ascertain... for example, to try to come up with 'anxiety-like behaviors'. It's very strange to talk about anxiety in a planarian, but remember, they like to be in the dark - they hide. So any type of compound that shifts that preference - that they don't care too much if they are in the light or in the dark while keeping the same degree of motility - is an indication of less anxiety, as it were.

And guess what? Antidepressants cause that effecting planarians. They shift that response. Those are not my experiments, but some other groups have done that.

Alie: Oh my gosh, that's so fascinating. Wow!

Aside: P.S: I looked this up and in a 2018 study titled "PLDT (Planarian Light/Dark Test)," researchers found that these critters hid in the dark when they smelled 'frog odor', but chilled out in the light when administered 1% ethanol - aka a booze bath - or what's known on the streets as bath salts, or fluoxetine - aka Prozac - a drug I have also taken to spend less time in the darkness. I'm gonna guess planarians had lower deductibles though.

Alie: Meghan McLean asked: Has anyone ever knowingly eaten them, and if so, what do they taste like? And Zoltán Szászi says: Asking the real questions here!

Oné: [laughs] You know what? You're not going to believe this but that's the strangest question I've ever gotten about planarians, but your listener was not the first one.

When my kids were at school - my youngest is 18 right now, but when my youngest was at school I used to go to their school all the time to show them the worms, and one year a kid

asked me precisely that question. When I asked, "Do you have any questions?" "Yeah, what do they taste like?"

And I was like, "Uhhh, okay..." I can honestly say that I've never eaten one. I don't think they will hurt you, but then again they live in pond water, which is not a sterile environment, so I wouldn't eat them. [giggles] But to each his own.

Alie: Rachel Weiss wants to know: Do worms have individual personalities or are they just like little bacteria? No offense, bacteria!

Oné: I don't know about personalities per say, but *behavior*... that's why we replicate experiments. Have you heard about the Harvard Law of Animal Behavior?

Alie: No!

Oné: It's not mine - I read it somewhere and I can't find the original reference, but it's something like this, and I'm probably paraphrasing it: regardless of how carefully your behavioral experiments are designed, your animals will do whatever the heck they want.

Aside: [as if over an old phone] "Under controlled experimental conditions of temperature, time, lighting, feeding, and training, the organism will behave as it damn well pleases." [back to normal] Writer and scholar Joel Garreau, 2009.

Oné: Planarians are a very good example of that - it's just like humans. For example, in a big enough population, let's suppose that three people get a migraine: one may need a certain medication, another may need just ibuprofen, and the third may just need coffee. Despite having the same basic genome there's enough genetic variabilities that may account for [different responses]. Pharmacogenetics is a whole field of science!

Aside: This variation in preferences is even true for *cloned* worms, which is making me have a gentle existential crisis about souls, and if they exist, where do I go when I die, and if there was another me would it be wearing matching socks?

Oné: There's clonal populations of planarians that people, over decades... For example, Professor Alejandro Sanchez Alvarado is one of the main people who work in planarians. They have a clonal population of planarians that they have been maintaining for decades.

Even in a clonal population, which means that they have the same genes, their behaviors can differ in the same way that two identical twins can differ in their tastes. One of them may like coffee and the other one may like tea, because most people forget that the environment is as important as the genes.

I mean, I guess in terms of personalities, they may display different personalities, but how do you ascertain the personality of a planarian? I don't know - I know *I'm* very charming, but I don't know how I can ascertain whether a planarian is charming?

Alie: [giggles] I guess you have to look and see how many planarians are around them, just listening to their stories...

Oné: Exactly.

Aside: Now, keepers of aquaria may be familiar with planarians as tank pests, just loitering around trying to eat your shrimpies, but Laura Stacey asked: How harmful can these wormies be?

Are planarians are dangerous to hoomans?

Oné: Not the freshwater type because they don't have any specific defense mechanism like venom or something, but some of the marine planarians have nasty toxins in them. Those can potentially harm a human if the human eats the planarian.

Alie: Oooof!

Aside: Marine planarians are called 'polyclads' and they look like if you rummaged around a Goodwill bin and pulled out a tuxedo shirt from 1968 but it was made of black and pink velvet, could breathe underwater, ate flesh, and had two dicks. [*boing-boing!*]

Alie: And now, as long as we're talking goss' about planarians, Mariah McGregor wants to know: Can you discuss penis fencing? Is penis fencing in saltwater planarians... is that a thing?

Oné: As far as I know, it's just in marine planarians. That particular activity is exactly what it sounds like. In general, flatworms are hermaphrodites - they have both sexes in them. In the marine planarians, the penis fencing activity, what happens is that they do what you imagine they do.

Aside: Kethry Warren, George Farrar, and Annette K also asked about this - I looked up a NatGeo video showing these seaworms penis fencing... I want you to know, right before it rolled, YouTube played an ad for backyard fencing. So, Google, *still* not able to distinguish that I want penis fencing, not penis *FENCING*.

Anyway, on their undersides, both worms jut out two little nubbins. They've got two dicks - but no one said they were giant - and I'll be frank with you, they look kind of like a tiny set of tatas. They can wrestle for an hour, like oceanic dick Jiu Jitsu until one is, in effect, tapped out.

Now, getting knocked up is calorically expensive, so...

Oné: Let's suppose that one is able to stab the other one... the one who is stabbed is the loser and gets pregnant.

Alie: Oh my god!

Oné: As far as I know, freshwater planarians do not engage... They are pretty decent organisms that do not engage in such activities. [*laughs*] [*"En garde!"*]

Alie: Juliebear wants to know: How old do the oldest planarians get?

Oné: Well, that's a very good question too, which nobody knows the answer to, for a couple of reasons. Planarians are very easy to kill. You can actually squish them, you can add chemicals to them, and actually they will die very dramatically. They won't just die. They die and disintegrate like in a movie or something like that.

Aside: Just poof, gone - just like ghosting your own funeral. Also, this one blew my mind... planarians don't need Botox.

Oné: Many species of planarians, they don't seem to display the phenomenon of senescence. They don't get old. All the biochemical markers of senescence, they are not present in certain species of planarians. Potentially, as long as you keep them and maintain them, they could be potentially immortal. Nobody knows exactly how they all live. Not all planarians are able to do that. But many species do.

Alie: Wow!

Aside: Okay... Okay, hold the phone - planarians slurp up other planarians, and either *disappear* into a poof, or they're maybe *immortal*. So, sexy vampires, kindly step aside - this Halloween, we're wearing full-body spandex worm outfits with googly eyes.

Alie: I think this is a great question. Nikki DeMarco wants to know, first-time question-asker: If they regenerate, do they remember what they've learned? Are they a whole new being?

Oné: Oh my God, that's an awesome question! We know part of the answer. In the 1950s and '60s, there were a series of controversial experiments about the retention of memory in regenerating planarians.

What they did was to train planarians to recoil from an electrical current or something like that, then they would cut their heads off. They would allow the bodies to regenerate their heads, and there seemed to be some indication that the tail remembered the stimulus. They were more easily trained to recoil from the stimulus.

But for the longest time, those experiments were controversial. They were called the James McConnell Experiments because many people criticized him because... Scientists can be vicious at criticizing each other. But then came Professor Mike Levin of Tufts University. He actually replicated McConnell's experiments in a controlled environment, unbiased, using computer observation and everything. And he was able to demonstrate a portion of McConnell's experiments. He trained planarians to recognize the roughness of a surface, and related that to the presence of food, and he cuts their heads off and yes, the tail did remember.

So that part is completely established, that could happen. Now, let's go back to the '60s. In the '60s, Dr. McConnell trained planarians to recoil from an electrical shock. Then they will grind those planarians, feed those planarians to naive planarians, and he claimed that the planarians who ate the trained planarians got their memories transferred to them.

Those experiments have not been replicated yet. Actually, Dr. McConnell was a very controversial figure. He was actually one of the victims of the Unabomber. The Unabomber sent a bomb to Dr. McConnell, and he was not killed, thankfully, but he was injured and everything because of his controversial brain experiments.

So, the memory transference in planarian deaths has not been established as far as I know, but that the rest of the body retains at least *some capacity* to remember. Yeah, that's pretty

much true. Pardon the pun, but it opens a can of worms because where are memories stored in the planarians? It's not exclusively in their brains, you know.

Alie: So it opens up a can of flatworms to figure out if it's a fluke or not?

Oné: *[laughs]* Oh yeah, that's another good one.

Alie: Oh my gosh, this is amazing!

Aside: I usually ask Ologists about movies or TV shows about their fields, but planarians? There's not gonna be a superhero about a cross-eyed flatworm.

Oné: There was a comic book about planarians called *Planarian Man*.

Alie: No!

Oné: Yes. That was the brain child of Mr. Neal Obermeyer, who is a very gifted editorial cartoonist from Nebraska. In the 1990s, he created that comic book *Planarian Man*. He was actually very kind to allow me to use some of his drawings in *The First Brain*.

Planarian Man, what better cartoon? And it has an origin story very similar to Spiderman.

Aside: I looked this up and Planarian Man's backstory was that he was dissecting a worm in biology class, and nicked his finger, and became one with the planarian. But in true regenerative fashion when parts of his body would get lopped off in combat they *themselves* would grow a new person. So his nemesis is mad Dr. Planarian who is like you, but if you were evil, which is just kind of, casually, each of our darkest fears.

Also, Oné told me that in a 1939 paper about planarian head duplication written by one Dr. Hamburger, the fused, multi-headed flatworms looked exactly like *Battlestar Galactica* raider ships? Really??

Oné: And when I saw that paper, "That looks like a Cylon!" And I said another expletive that I shouldn't say in the podcast. But you can find connections everywhere with this topic.

Alie: Now, as amazing as planaria are, there must be something annoying about them. There must be something that you hate about planarians.

Oné: Something that I hate about planarians, let me see... *[Jeopardy! theme music plays]*

Actually, no. I *love* them!

Aside: Ah, this guy! I love Oné like Oné loves worms. But come on, there's *gotta* be something bad...

Alie: Do they smell?

Oné: Not that I know of, because they come in pond water, and as long as you change the water regularly, they don't smell. And they're such cute critters - they're a source of fascination, it's just playing really. Really, what I do is play with worms - I just play with worms, that's what I do.

Alie: Is there anything about your job that you hate?

Oné: About my job? No... I love teaching, and of course I love talking about science, reading about science... I love doing research because there's something about discovering something that you know, or you're very sure that you're the first person that's ever learned about it, and it's an indescribable feeling! I can't for the life of me tell you anything that I don't like about my job!

Alie: [laughs] That's amazing!

Oné: I don't like administration that much, because I know my limitations, and I know that I would be a very *bad* administrator - that's for sure. My hat's off to people who can do bureaucracy and all that.

Alie: [giggles] I'm pretty bad at it too.

What about your very, very *favorite* thing - in terms of work or these critters?

Oné: I love data - I love when I'm able to get some numbers and then graph them and analyze to try to find a particular phenomenon that I can ascertain from that. I love my data, I love analyzing data. I'm intending to learn a lot more microscopy than I know so I can apply some fluorescent compounds to planarians so they can tag specific receptors and we can actually trace nerve cells. I want to learn how to do that - we have all the equipment at the university. I hope we can open soon so we can do that.

Alie: I hope so too!! Are you keeping busy at home at all? Can you be working on your data at home?

Oné: Actually I have a bunch of data that I'm writing up. As you can imagine, the university went all online. I was furiously converting my class to online mode. In every semester I have an average of about 600 students depending on how many courses I teach - so it's a big undertaking to do that. And I want to say again 'Hi' to all my fellow faculty members and my students at West Chester because we're all in this together, and we're gonna get through this. But it's been an uphill... let's put it in academic terms: It's been a steep learning curve to do everything online.

Alie: I bet.

Oné: Yeah, because one of my techniques to teach is that I tell very bad jokes! I am a dad, okay? I love doing dad jokes, but the real reason why I teach with bad jokes in class is because we are all conditioned to a few minutes of close attention followed by distractions! Commercials, cell phone, or a text, whatever. So when I see a significant fraction of my class is not quite there, if you know what I mean, ["*Bueller?*"] I crack a stupid joke. I get a courtesy laugh, or a pity smile, or a groan, or an eye roll, but at any rate I reset their attention and bring them back to me. I can't do that online! So a big part of my technique I can't use right now, but I'll make do!

Aside: Meanwhile, you can find him at his blog BaldScientist.Wordpress.com and on Twitter @BaldScientist. I love his tweets, he's got his pronouns in his bio, and is just a warm, wonderful person to add to your timelines, trust me. We love to see it.

Oné: I love answering questions, I love meeting like-minded people, as I said before. I love Science Twitter. That's where you can find me.

Alie: Oh my gosh, this was *so* fun, thank you so much for doing this!

Oné: Thank you for the opportunity. I really appreciate it - you can't fake this, I'm too enthusiastic about these things. Thank you, thank you, thank you!

So you know the drill, whether by FaceTime, or whispered over a landline, or bellowed through the muffle of a mask from 6 feet away - ask smart people stupid questions because we're all going to be dust one day and who gives a rat's ass. It's cool to know stuff.

If you're now besotted with a friendly worm expert, again follow Dr. Pagán on Twitter [@baldscientist](#) or at his blog, also [BaldScientist.Wordpress.com](#); I'll link those both of those in the show notes alongside sponsors of the show, and No Kid Hungry. More links and research are up at [Alieward.com/Ologies/Planariology](#) and that link will be in the show notes too. Your cat may be on your lap, and you probably don't have a pen - it's fine.

Come be friends with us on [Instagram](#) or [Twitter](#) we're @Ologies on both and I'm on [both](#) as [Alie Ward](#). For Ologies sweatshirts, and hats, and totes, and stuff, you can head on over to [OlogiesMerch.com](#). Thank you Boni Dutch and Shannon Feltus for that; they host the comedy podcast *You Are That*. Thank you to every single Patron that supports the show on [Patreon.com/Ologies](#). Erin Talbert admin's the [Ologies Podcast Facebook group](#).

Thank you Emily White and all the Ologies transcribers for making transcripts available, and Caleb Patton for bleeping episodes to make them kid safe - good luck with this one. Transcripts and bleeped episodes are up at [AlieWard.com/Ologies-Extras](#). Thank you Noel Dilworth for scheduling and so much other help, Kelly Dwyer for webmastering, and congrats on the brand new babe! Also you can check out her husband Matt Dwyer's podcast, *Conversations with Matt Dwyer*. It's so, so good. I happen to be his guest this week, but check out his back catalog, it's *so* good.

Jarrett Sleeper of Mindjam media also hosts *My Good Bad Brain*, a mental health podcast - thank you Jarrett for assistant editing, this one took *so many* extra hours because we had a lag in the remote recording service we use. It was just a nightmare to edit, and he and Steven did an amazing job. So thank you of course to the bemustached Steven Ray Morris who hosts the podcasts the *Purrrcast* and *See Jurassic Right* for lead editing.

And if you stick around until the end you are rewarded with a bonus truth nugget. This week I finally figured out that I might be a little more snacky and sluggish at home partly because I'm not drinking enough water, 'cause I never use my insulated water bottle at home - that's usually like a 'leaving the house' thing. And that thing keeps shit *ice cold*. And a little fun fact about Old Dad Ward; room temperature water is *disgusting* to me. Uughh! And water that's been sitting out for a while that might have dust in it is also gross, and I think that's from seeing *Science* by M. Night Shyamalan in the theater 20 years ago. But I just started filling my insulated water bottle with iced water to drink and I think it's helping. Just a little fun tidbit.

So stay hydrated and raise a glass to all the planarians who bravely underwent research and are saving other animals' lives. Thanks, planarians! Not to end on a sad note, I meant that in a good way, but... thanks planarians. Okay berbye!

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