

# Hagfishology with Dr. Tim Winegard

## Ologies Podcast

### April 16, 2019

Ohaaay it's your uncle's army buddy who makes superb banana bread, Alie Ward, back with another episode of *Ologies*. First off, I know you. You're either like, "The fuck is a hagfish?" or you're like, "Aaaah yes, hagfish! But an hour of hagfish?" Oh yeah. Oh yeah. Here's a secret you need to know: We are all hagfish. We're shy sometimes but we have friends, we have preferences, we can make do, we have hidden talents, sometimes people underestimate us until they realize our superpowers and then they stand back and they marvel, and by marvel, I mean listen to a whole episode about hagfish.

But before we dive into the deep sea of this slimy hour, let's first, by tradition, thank all the folks on [Patreon.com/Ologies](https://patreon.com/Ologies) who make these episodes possible - we'll hear some of their hagfish queries later! - and to all the folks buying Ologies merch at the link in the show notes and sporting it. And of course to all of you kind souls who have rated and subscribed to the pod and also left your reviews for ol' Dadward, which I read by lantern light with a tear in my eye. This week Jen Bagels just wrote:

*Alie, I hope you really do read every review because I want you to know that the world is a better place because you're in it.*

I don't deserve that! That's too nice! Don't make me cry. K sup HD, which I guess I'm realizing just now is KSU PhD, so sorry, says:

*Here's a tip: don't cherry-pick the episodes you think you'll be interested in, just binge them all. They're all delightful!*

Thanks, K sup HD. Okay! Hagfish, Haaaaagfish.

Okay, first off, you're going to have to wait to hear how hagfish got its name. Sorry, it was a common Patreon question so we're gonna address it later. This is as clickbaity as I get. Secondly, YES, the term 'hagfishology' has been used before, I did not make it up. A 2013 biology graduate students' seminar schedule included the talk, *Adventures in Hagfishology: Sulphate transport and extra-branchial mechanisms of ion regulation in Pacific Hagfish*, by Alex Clifford. So Hagfishology: the title's legit, haters.

This episode exists because science journalist Ed Yong wrote an article for the *Atlantic* in January with the headline "No One Is Prepared for Hagfish Slime", and he was SO right. It included photos from a 2017 traffic accident in Oregon in which 7,500 pounds of hagfish tipped over on a winding, forested highway and slicked the roads and the cars in incomprehensible amounts of slime. I immediately started googling 'hagfish scientists.' I had a few on the list and was thrilled to see that they were based in Southern California. They were on my spreadsheet.

A few weeks ago, my friend, wildlife educator Mallory Lindsey, who is amazing, went to the same lab! I messaged her and I was like, "I'VE BEEN WANTING TO DO AN EPISODE ON THIS. HOW ARE THEY?" The next day, my phone rang; it was a hagfishologist, just using the phone, like it was 1997! So charming. So we met a few days later on a street corner near Chapman campus in Orange County, he has a bright smile, surfer-esque golden hair, and a ruddy beard, and we drove around

looking for parking because, again this is Southern California, and then we hit the lab and he showed me gurgling, chilly, saltwater tanks filled with a few dozen soft, pinkish-purple-grey floppy hot dogs with mouths.

He let me cradle one in my open palm, and it felt like a very floppy hot dog. Like if God put a face on an intestine and just stopped there. Were these specimens slimy? Not really, until this ologist urged me to annoy one. "Give it a little pinch," he coaxed. Milliseconds later, it seemed, my hand was drenched in a thick veil of elephant snot. I was transfixed. Hagfish are disgusting AND they deserve our respect.

This ologist, as you will hear from the dulcet tones of his Canadian accent, hails from the North and got his Bachelor's and Master's studying Zoology at the University of Guelph. Whilst there, he happened to take an invertebrate zoology class with hagfish master, Dr. Douglas Fudge, with whom he now works as a research associate at Chapman.

So, prepare to hear about swift escapes, outlasting extinction events, the mysteries of the deep, why you - I guess - don't always need a spine, eating your way out of a dead thing, disappearing without a trace, and, like a slippery messiah, converting water into slime, with human delight and professional Hagfishologist, Tim Winegard.

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**Alie Ward:** I don't know if you know this, but you are technically a hagfishologist.

**Dr. Tim Winegard:** I don't know if I've ever heard it put that way, but I'm probably one of few, yeah! *[laughs]*

**Alie:** I looked it up to see if there was a more Latin-sounding name, and the term that's been used the most to describe what you study is literally hagfishology. People have used that word before, *[laughs]* so it's a thing, hagfishology.

**Tim:** Let's go with, we'll run with it.

**Alie:** What is a hagfish, for someone who's never seen or touched one?

**Tim:** I guess the best way to describe them is they are a benthic deep-sea dweller; essentially all hagfish share that in common. They all live along the bottom substrate of the oceans and the majority of them below a hundred meters in depth, or about 300 feet.

**Aside:** This ologist jumps between metric and U.S.-why-are-we-still-not-metric measurement, so I don't have to convert it. Thank friggin god.

**Tim:** What they are is a jawless, primitive, eel-like creature. I'm hesitant to call them a fish, even though it's in their name, because they aren't necessarily a traditional fish. They lack scales, they lack jaws, they lack eyes, they lack what we traditionally refer to as fins. So, in many ways, they're a very primitive version of a modern-day fish. They are thought to have diverged at around the same time that vertebrates popped up on the evolutionary spectrum.

**Alie:** So, these suckers are old! *[clip from The Simpsons: "My GOD you're so old."]* How many millions of years do you think?

**Tim:** There is fossil evidence up to 350 million years, but they're likely over 500 million years old; among some of the first really highly organized cephalized - which essentially means head-focused - creatures. Hagfish, for a long time were defined as craniates, which means that they have a cranium surrounding their brain, but they have no calcification of anything in their body, so it's all cartilage. They do have a notochord, they have many of these features that are very vertebrate, in a way, but lacking calcification, lacking gills, lacking jaws, all these other features place them in a much more... I even hesitate to say primitive, but I guess they are primitive features. Even though hagfish themselves are... obviously, as ancient as they are, they're also very modern. The hagfish we see today, we really don't know how much they relate to the hagfish of the past.

**Aside:** P.S. If you're like, "Notochord?" I got you. A notochord is, by definition, a 'cartilaginous skeletal rod supporting the body'. You had one! You had one as a teeny tiny embryo. It's like a backbone in that it gives support and structure, but it's not a backbone in that it's not bony, segmented vertebrae. Oh, and the hagfish has a brain case that isn't a skull, it's a little cartilage rib cage around their brain lump. And in the hagfish world, there has been decades of heated, dramatic - that's how I like to imagine it - debate on whether hagfish never developed a backbone, or if they had one and then just devolved the other way to gradually get rid of the sucker. Oh, and their eyes, and their skull. Kind of like a handsome, lanky drifter, who is also slimy and eats corpses; their backstory is still a mystery.

**Tim:** Through fossil evidence, of which there are only two, it makes it a bit of a limited jump in terms of what you can say.

**Alie:** There's *two* fossils of Hagfish?

**Tim:** Yeah. Soft-bodied creatures don't fossilize well. When they die and end up in the bottom sediment, their tissues are so similar to everything else around them that they don't end up distinct, like other animals with calcium or real bones in their body do.

**Alie:** Who's got those two fossils? Where are they?

**Tim:** That's a good question. One of them was just discovered and published by a group in Alberta, and then the other one - that's a good question. It's been quite a while since I read the paper, but they would be in museums; there's only two of them known.

**Aside:** Y'all, I spent so long trying to find out where these two fossils are, and I can tell you that one was discovered in Mazon Creek, Illinois, I think around 1991, and the other is from Lebanon and was acquired in 2013 by a private fossil-collecting company. I earnestly just spent two hours trying to figure out if I could go on a road trip and see a hagfish fossil in person. And the lack of information on their whereabouts has led me to believe that they're both kept in a subterranean vault with the holy grail, or they're kicking it, like ballers, in a timeshare with Bigfoot.

**Alie:** So precious.

**Tim:** Yeah. Super precious, and like I was saying, very rare, but as we uncover more fossil beds, there are particular fossilization conditions that lend themselves to preserving soft-bodied animals better. I think there was just a big deposit found in China in the last couple of weeks

that has a lot of soft-bodied creatures, but I think it's more in the 350-million, 450-million-year range.

**Alie:** Going back a little bit less far than that; your history. When you were just a tiny tot in [*goofy voice*] Canadia, did you always love poking around lakes and forests? What was going on?

**Tim:** Oh yeah, for sure. My mom always used to say that if she needed to distract me, she would just say that she saw something in that puddle [*laughs*] and I'd be pretty consumed for quite a while. [*clip from Kendrick Lamar song King Kunta: "Something's in the water, something's in the water."*] Honestly, I don't think there's a time when I didn't like science in some way. I wanted microscopes when I was six and brought home every creepy-crawly I could find. Actually, I collected butterflies, my original plan as a child was to be an entomologist.

**Alie:** Really?

**Tim:** Yeah. I collected large numbers of butterflies from all over the world, wherever we went.

**Alie:** And then where did you flutter away from them and into a hagfish tank?

**Tim:** That would have been in university when, I guess, the opportunities to study tropical butterflies were limited in Canada, [*laughs*] [*"It's butterfly time."*] so that's when it happened. I think it was right around 2007, through meeting Doug and getting introduced to hagfish, and then sort of being brought into the fold, as it was, into the world of hagfish. There's, sort of, no end of amazement; that's what's kept me here. That almost any question you can ask about hagfish, there likely isn't a concrete answer.

**Alie:** And so, when Doug said, "Hey, come on back, study some hagfish with me." what was your response to that?

**Tim:** Oh, I think it took a bit of prodding because I really did enjoy the Wildlife Research Station and living out in the woods there. But you know, obviously we're sitting here in beautiful, sunny, Southern California, which didn't hurt.

**Aside:** Have you heard a more Canadian sentence: [*"I really did enjoy the Wildlife Research Station and living out in the woods there."*] And Tim says he loves doing applied research on these critters, figuring out how to use the slime to inform human-made alternatives. His master's work was looking at how we can use these 15cm-long threads that spring forth from the hagfish as a fiber source and get away from petrochemical-based fibers, like acrylic, nylon, and polyester. So, although he misses the wilderness, trading in his parka for board shorts wasn't all that tough.

**Tim:** I think that my heart's always been into hagfish. In some ways, I think it didn't take too much! I think that the right projects, the right people, all sort of lend themselves to a good time in science.

**Alie:** And so, explain to me what the life of a hagfish is like. Where are they living? What are they eating? Who are they hanging out with? What's going on down there?

**Tim:** I think we all wish we knew. What we do know is that they're very sensitive to temperature and light, so they are a deep-sea specialist, they seek out cold water. There is maybe only one species that's found inside of a hundred meters of depth, called the inshore hagfish (which is found in Japan), but other than that, they're all very deep-sea. They feed on a

variety of not only small tube worms and other invertebrates, but also scavenge large windfalls of whales, and seals, and sea lions, and big fish that fall down into the ocean deep. [*“That’s deep.”*]

**Aside:** Remember the Teuthology episode with Sarah MacAnulty about marine snow? That soft, steady, underwater dusting of poo and flesh chunks? Well, a dead whale is like a marine blizzard, and hagfish love a snow day.

**Tim:** We know, or at least we think, that they play an important role in that bottom composition turnover. When things do fall into the deep, there are conditions that can lend themselves to preserving something like a whale for years; low temperatures, low oxygen, so maybe the bacterial decomposition is not as prevalent. There would be bacterial decomposition, but I think there’s a place for hagfish in actually cleaning up the bottom in that way, and then spreading the nutrients around. So as they feed, they obviously leave, go back to their burrows or go back to where they’re living, and bring nutrients with them, and essentially help spread nutrients in an otherwise very desert-like deep sea environment.

**Aside:** [*Alie, rapping: “Smell it, find it, munch it, poop it, spread it.”*]

**Alie:** We were looking in the tank and some of them are all coiled up, some of them are just hanging out in a tube. What’s their day-to-day life like?

**Tim:** In terms of what we know about where they live, some have a tendency to be in more muddy, sandy bottoms. Those species are typical burrowers, they’ll actually live in burrows in the mud, and typically sit there with just their nostril sticking out, looking for whiffs of whale or seals. But the other ones do spend time on rocky bottoms and I think those are the species that tend to coil up a bit more, because they’re just spending a lot more time on the surface as opposed to within the substrate.

There’s been interesting work as well showing that hagfish have handedness. They have a tendency to coil either right or left, more than the other way, so they have a preference. I think in captivity there’s probably only, maybe, five or six common species for people to have in captivity. There are a number of species that do not do well at all, so they’re really hard to keep in artificial environments, essentially. I think partially that’s because it’s really hard to replicate the pressure that they’re used to living in. We can replicate temperature, and salinity, and pH, and all these other environmental parameters, but it’s really hard to recreate being a mile below the surface of the ocean.

**Alie:** Right. And how are they making baby hagfish?

**Tim:** Nobody knows.

**Alie:** WHAT!

**Tim:** Yeah. Nobody has ever witnessed hagfish breeding.

**Alie:** Wow.

**Tim:** Nobody has ever had hagfish successfully breed in captivity, even unseen, to produce fertile eggs. So, we have hagfish laying eggs in captivity all the time, but they’re presumably unfertilized because they never develop. This is something that I’m really interested in as well: Is there seasonality in the deep sea? Even though it’s dark and cold all year, are they

more attuned to those deep-sea conditions and maybe sense the difference in lunar phases? Do they have a migration? Are they always in the same place all the time? I think that they are moving throughout the season, but not a lot is known about it because it's so hard to follow these things into the deep.

A lot of the technology that's used for tracking fish and other stuff isn't at either the size scale that could be used in hagfish, or the fish need to come to the surface to get data pings and hagfish never will. They're really tough to follow. We've got a new underwater video rig that we're going to use to try and at least peer into their lives a little bit.

**Alie:** Would you think that they would be following the whales in case a whale does bite the dust and falls down?

**Tim:** I think whales are typically undergoing such large migrations that hagfish wouldn't be, say, following the herd. I think their low metabolism suits them well to possibly go a year or more without feeding. Even in captivity, we typically only feed them every three to six months.

**Alie:** What?! [*slowed down: "Whaaaat?"*]

**Tim:** Yeah. Yeah. They eat a lot, when they eat, but they don't eat frequently.

**Alie:** Wow. What do you feed them in captivity?

**Tim:** They get a bit of a mixture. There's shrimp, and squid, and beef, and sometimes other random large fish that we come across in our work. I think we fed them an opah, which is a very interesting fish.

**Aside:** Okay so quick aside, researching opah got a lot of hits on Oprah. It's a different thing. An opah is a big, silvery, round fish, also called a moonfish - it looks like a moon - and opah are one of the rare endothermic fishes, which means, like Oprah, it has a warm heart.

**Tim:** We feed them a diversity of stuff, hopefully trying to get them the right nutritional requirements they need. But again, it's something that is not really well understood, and something that we're looking to do more on is gathering gut contents from hagfish.

**Alie:** Would you just drop like a pot roast in the tank and they go nuts on it?

**Tim:** Essentially. Yeah.

**Alie:** What does that look like?

**Tim:** It's a bit of a feeding frenzy. They're all going at it. It's really interesting as well, though, because they lack appendages and they don't have a jaw. If it is actually a big pot roast, they actually tie themselves into knots that they slide against the pot roast to actually tug on it.

**Alie:** Oh my God.

**Tim:** Yeah. So, they tie the same knots to rid themselves of slime, but they have a very unique way of actually latching onto something without jaws.

**Alie:** So, they can pull at it and get some resistance?

**Tim:** Exactly.

**Alie:** Have you ever seen a hagfish eating a whale?

**Tim:** Only in film. I've never seen it in real life, I would love to.

**Alie:** Do they go into the whale and then borrow out?

**Tim:** Yeah, they are definitely spending a lot of time inside the whale. A recent study was published actually showing that they can absorb amino acids across their skin. So, part of their low metabolism, their ability to deal with low oxygen, all of these unique adaptations really allow them to live that lifestyle [*Jacob from Twilight: "It's not a lifestyle choice, Bella."*] and to go into a whale, in which oxygen concentrations could be quite low, bacterial levels high, all this other stuff, they're perfectly at home, may feed there for months on end.

**Alie:** For months! Just gorging, and then be like, bye-bye, and then go hang out for a year. Wow, that's so efficient, I have to say. Good for them, they take on a lot of cargo and then just kick it for a bit.

**Tim:** Yeah. I think we see that with anything that has withstood the test of hundreds of millions of years. That they're typically generalists, right? You know, something like a crocodile can eat anything, can go months and months without eating. There's certain life history characteristics that lend themselves to withstanding mass extinctions and all of the climatic changes that impact very niche-specific species.

**Aside:** After this interview, Tim and I went and ate tacos, and I realized later that, despite flinging around wet loaves of hagfish mucus in the lab earlier, neither one of us washed our hands. But we also had a spirited discussion about the importance of a diverse microbiome, so I think we were on the same "so what" page there.

Also, at lunch he mentioned that the hagfish traps are like buckets with a few conical ports that funnel the hagfish in so they can't get out. What do they use to lure them into the bucket? Turns out that hagfish love the smell of big mammal bones and fat, so they toss a fleshy beef bone in there, and I was like, "Do they get to eat it?", and he's like, "Nah, that would mess up their gut content data." So the beef bones are in a mesh bag, meaning that the hagfish smell it, find it, but can't munch it, poop it or spread it. The hagfish have been catfished.

**Alie:** They tend to eat the bigger things like a whale, a sea lion? Is that kind of what their bread and butter is, it's all, "Man, there's a big whale. It's big and dead floating down here. It's Thanksgiving!" What's happening?

**Tim:** Yeah. I think that's the real train of thought that we're on, essentially that a lot of their features, a lot of their adaptations, would lend themselves to really capitalizing on those big whale falls or big mammal falls. They have very low metabolisms. If you compared them to a vertebrate, they'd have one of the lowest metabolisms of any vertebrate.

**Alie:** Really??

**Tim:** Yeah, they live slow. [*repeated in slo-mo: "They liiiiive sloooooow."*] We've observed them absolutely gorging at these deep-sea sites, so they just fill their guts to the point that they may be many times their original mass. [*clip from Game of Thrones: "I was hungry."*] To be able to do that makes you think that this is predominantly what they're doing, but we also

see that they do feed on tube worms and these other invertebrates that are found in the sediment in which the hagfish live.

**Alie:** Can you run me through some body parts of a hagfish?

**Tim:** Yeah. I guess if you're to have a hagfish out on the table, they do have a head, and they have barbells at the end of the head, which are essentially their chemical-sensing devices.

**Alie:** Is that like a catfish?

**Tim:** Catfish have barbels as well, so yeah. They'd be packed with what we call 'chemosensory cells' that would be picking up things like the scent of dead or decaying fish, or a whale. They start with those, then they have a very large intake aperture for their gill system.

**Aside:** Seawater gets snorkeled through their face snoot, and then that water is expelled through these breathing holes on the side. They're kinda like a slimy water flute that someone sewed from a de-boned baby. Anyway, they smell like champs.

**Tim:** It also feeds into a sack very close to their brain. They have, probably, an incredible ability to detect very faint smells, which makes sense if they're potentially hundreds of meters from something that fell, or maybe even further.

They have very primitive eyes. If you look at a lot of the hagfish they don't have the type of eyes that we would normally associate with a fish. Theirs actually don't even protrude through the skin; there is a transparent layer of skin that covers a very rudimentary eye, that was likely more developed at one time, but was just not selected for, and they essentially lost its full functionality.

**Aside:** So, eyes? Pffft. We're off that. Had 'em, lost 'em. Baller. Now what's happening with that mouth? First of all, it has these whiskery flesh-dangles that look kinda like a tiny handlebar mustache made outta little dicks. But don't go looking for jaws here. No, no sir. They have what Tim calls a 'muscular appendage' inside their mouth, and it juts out this little paddle of hard, jagged spikes, kinda like a snail's tongue. Imagine if your tongue had rows and rows of those things in parking lots that will pop your tires if you drive the wrong way on them. So yeah, hagfish; they deserve our respect.

**Tim:** Essentially, there are these keratinous teeth, the same material that makes up our fingernails makes up their rasp, which they use to essentially sand tissue off of a carcass, or to slurp up a little worm that they're after. Then when you look at the rest of them, they vary a little bit in terms of their gill apertures that water flows out of. The more burrowing specialist hagfish will have reduced numbers of gill openings in which the water flows out of.

**Aside:** Again, water flute. Now all of this is just the tater-skins, the jalapeno poppers, appetizers before we get to the main course because here's where things get slimy. Now, if you've listened to previous episodes of *Ologies*, or the first 12 seconds of this one, you know that I don't censor language. [*"The fuck is a hagfish?"*] Most science podcasts bleep out questionable swear words, but I embrace raw emotion and freedom of adult expression in science communication (in this podcast at least) with the exception of the word... mucus. It's too gross. It comes up between 10-15 times in the remainder of this episode. So, when you hear a faint chime, [*mucus ding*] please know it's replacing the word mucus. Please feel



free to take a glug of your beverage in front of you, or do a tiny imperceptible butt dance to celebrate the absence of this word.

**Tim:** And then as you move into the rest of the body, you'll notice along the ventral side that they have about a 100-150 slime gland openings. They're literally covered head to tail with these glands that produce their defensive slime. Whether they're bitten on the head or on the tail, they can, in a fraction of a second, like less than 100 milliseconds, produce copious quantities of this fiber-reinforced slime. [*splat*]

**Alie:** Which is... Astounding. [*Riff Raff from The Rocky Horror Picture Show: "It's astounding."*] For something that is maybe not as advanced as some other vertebrates, this is a defense system that is still very much mysterious, in terms of how it works, right?

**Tim:** I think, yeah. If everything else about the hagfish, we would call "primitive," this is highly derived. This is unlike anything else found in nature. We know of a lot of mucuses, we know of a lot of natural fiber sources like silkworm silks or spider silks, but the hagfish threads that are found in their slime are not only comparative to spider silks, in terms of their mechanical properties, that they're incredibly tough, but they produce this stuff in prodigious quantities.

**Aside:** This cannot be overstated.

**Tim:** An individual hagfish may have 20,000 kilometers of fiber in its body at any one time. And what's so unique about these fibers is that they're packaged into 15cm fiber lengths, but that's coiled into 150-micron cell, so in a little bit more than a 10th of a millimeter, they pack 15cm of thread into.

**Aside:** To put that into perspective, the threads that make up this water-trapping slime network are 10 million times longer than they are wide, and they are somehow neatly coiled like a skein of yarn into a tiny cell capsule, ready to be ejected and unfurl. More on how that works in a minute – but admit it, you love hagfish. How are they coiling this? What is their gooey witchcraft? You are intrigued.

**Tim:** That process, in and of itself, has been something that has really intrigued us for quite some time.

**Alie:** Is it hard for them to make more of it? If they slime someone and they're like, "Bye, bye!" [*clip from Broad City: "Later."*] do they have to go sit and produce more? Is that energy expensive for them?

**Tim:** The fibers are made up of protein, which in general is quite expensive to make, but one of the unique things that the hagfish does by having so many slime glands is that it never deploys them all at once. They do have some site specificity; if you bite it on the tail, it may only release exudate, which is what we call the condensed slime... It may only release a few glands worth, like two or three glands on either side of its body, which is enough to produce a gallon of form slime. So, like, they would never be caught without slime, ever. They just have so much on board, and there's some indication as well that they can't actually release all of the slime from a single gland, because they likely retain the immature cell components, which would otherwise maybe be released, but not function as they should.

**Alie:** What happens when these fibers hit water?

**Tim:** That's something that's really interesting to us. It's a two-component slime. It's released by what's called 'holocrine secretion', which means that the cells are actually having their membranes stripped off of them as they go through the pore of the slime gland. It narrows down to a tiny opening that strips the cells of their membranes, so that when they're released to sea water, they are exposed to an entirely new environment. [Kate Holbrook from *Baby Mama: "Water!"*] There's an interaction with the seawater, essentially the solubilization of proteins that help maintain these fibers in their coiled-up state, but what happens is that the seawater very rapidly bursts the m\* [ding] vesicles that are released, they shear out into these long strands, which essentially transmit forces of mixing down to the thread bundles.

**Aside:** [sports commentator effect] Instant replay.... aaaand the hagfish takes the offense, defense ejects tiny coiled balls of the exudate, getting their little membrane covers stripped as they exit. The threads hit the water and exxxxpand, trapping more water in a net of microfiber threads, expanding TEN! THOUSAND! times its size Slime! Predator offense retreats, down for the count, hagfish remains the champion of the deep!

Or in Tim's words:

**Tim:** To simplify what I just said, the m\* [ding] is released, really vigorous mixing that's created by either the hagfish trying to escape or the predator trying to eat the hagfish further expands this network of m\* [ding] and fiber, until it forms this fully formed slime ball, which is capable of fully clogging the gills of a 10-foot shark. We've never seen a successful predation on a hagfish by any gill-breathing predator. We see sea lions, birds, porpoises, these are all successful hagfish predators because their breathing mechanisms are separated from their eating mechanism, essentially, just like us. We can breathe and eat at the same time, whereas most gill-breathing fish can't. They're breathing all the time, and that is what exposes them to the slime.

**Aside:** So... Ya got gills? Ya got screwed.

**Alie:** That slime will just clog their actual respiration, and they're like, "I'm out."?

**Tim:** Exactly. It shuts the water flow from going across their gills, and we actually don't know what happens to them, because all of the video work that's been done has happened with wild, free-living animals. When the sharks or the fish gets slimed, they quickly leave the video frame, and we actually don't know whether they actually die, or whether any of these animals can get the slime off their gills. It just gets wrapped around everything with miles and miles of fiber, it's very easy for it to just get wrapped around things and stay there. [laughs]

**Alie:** Man. And so, how much of this slime is actually water, and how much is the fiber protein?

**Tim:** So, when the exudate is released into seawater and fully sets up, it is over 99% seawater. Essentially, hagfish slime can be formed in any container, it'll conform to the shape of almost anything. We did a study that showed that it's actually one of the softest materials known to man; it's very deformable.

**Aside:** This study was "Concentration-independent mechanics and structure of hagfish slime" and one of the paper's authors, Randy Ewoldt, told the *Atlantic's* Ed Yong that hagfish

slime is one of the softest materials ever measured and, “Jell-O is between 10,000 and 100,000 times stiffer than hagfish slime.” I have touched it, and it’s some soft, silky business, and then I went and touched nachos, because I’m 10,000 times tougher than Purell, apparently.

**Tim:** But when it's put into elongational flow or stretched, that’s when the fibers and the reinforcement properties start to be felt, because they're actually incredibly strong when you stretch them.

**Alie:** What do you think are some applications of hagfish slime? Are people looking at this being like, [*conspiratorial laugh*] “Mwahaha!”?

**Tim:** I think so. It's such a unique mechanism. I think, first of all, the speed with which the slime sets up interests people, because whatever is happening (and we've been trying to figure this out for years) happens so quickly that it's likely one of the fastest reactions that we know of, it's so incredibly fast. I think we could maybe learn not only how to bundle, unbundle or uncoil things, but also how to develop rapidly expanding gel networks; that could be an interesting application. The fibers themselves, I've always been interested in actually using for textile. They're very, very fine; they are micron in diameter. Even when you think of microfiber clothing, which is so soft, that stuff is like 30 to 50 microns in diameter, so it's much finer.

**Aside:** Let’s get some scale for microns, real quick. A micron is one millionth of a meter, and a human hair is around 50-100 microns in diameter. A red blood cell is 5 microns across. The human eye can’t see much smaller than around 40 microns. So yes, hagfish silk would be luxurious as hell.

**Tim:** It would probably make THE softest t-shirt. [*laughs*]

**Alie:** What would you have to do to get it from a puddle of m\* [*ding*] to a loom? Would you have to dry it out?

**Tim:** I think that you'd probably want to isolate the thread bundles and then work with them on their own. I think the biggest challenge right now is that it is such a narrow fiber that any of the equipment that's used right now to spin textiles is not built at a scale that could handle it.

**Alie:** Now, there’s a picture that went around the Internet that made everyone question what the deal was with hagfish, this photo of a car that got into an accident and it was carrying a ton of hagfish and there was slime EVERYWHERE. [*clip from The Matrix: “It is all around us.”*] Can you give me any backstory, or any thoughts on that?

**Tim:** Well, there is a commercial hagfish fishery; hagfish are used as food products in places like Korea, they’re eaten, but also, for a quite a few years, their skin was used to make “eel skin leather” products. So, if anybody has something that's called eel skin leather, it's actually probably hagfish. They made belts and wallets and handbags, and still do to this day. It's likely that that transport had a bunch of hagfish that were going to market and when it got into the accident, it stressed the hagfish out, and they started producing slime.

**Aside:** So, this happened on the coast of Oregon near Depoe Bay, and the photos are [*whispering*] bananas. It looks like these giant earthworms covered in silvery ectoplasm, on

a two-lane highway, covering the whole thing. They're slithering toward the gutter, a 4-car pileup looks like a giant sneezed on it. There are bulldozers scooping up slime eels, as they're called, by the hundreds. They're hosing off the road with 5,000 gallons of water, and then just letting them die there on the shoulder. Hagfish, quite frankly, deserve more respect. The local CBS affiliate was on the scene.

*[clip from the CBS News YouTube clip]*

*"I had no choice but to get out, and I was walking in it. [laughs] It was ugly."*

*"An errant butler had a miss with all that fish!"*

*"On the ground... It was still moving. It was liquid eels!"*

**Alie:** Oh, poor hagfish.

**Tim:** Yeah.

**Alie:** Can you imagine if we did that when we were just stressed out? Like, "I'm having a day, guys. I'm covered in m\* [ding]." *[laughing]* Is there a difference between m\* [ding] and slime?

**Tim:** Well, I think that's a good question. I'm not sure how much 'slime' is a technical term. I think that maybe all slimes have m\* [ding].

**Alie:** Okay.

**Tim:** You know, but maybe not all m\* [ding] are slimes. *[laughing]*

**Alie:** It's very possible. *[laughing]*

**Tim:** Yeah, like with hagfish slime, maybe we call it a slime because it's a two-part system. Whereas something like a snail that leaves a m\*[ding] trail, it's really just m\* [ding]. Maybe that's what it is, but I guess you call it snail slime too.

**Alie:** Yeah. I'm going look that up.

**Aside:** Okay, I looked into this distinction and the M-word is made by membranes and 'slime' is derived from the root word for sticky mud or marsh, but it now also means "ding" (you know what I mean). Different roots but technically now interchangeable. Just in case you need that in your everyday life.

**Alie:** Your day-to-day work with hagfish, what does it involve? What are you looking at? What's the process?

**Tim:** Well, my work right now is looking at whether or not hagfish slime can be used to essentially block the flow of water around different objects, like a boat propeller or a grate system, or how we can use its natural tendency to clog and reduce water flow in useful ways. One idea might be that you can mix it into an oil slick, and bind the water and the oil into it, and then remove it that way. That's not something we're currently working on, but I always had that interest – in that it mops up water so well – that I'd be interested to see what it could do with potential contamination and waterways and other things.

**Alie:** How do you think hagfish are portrayed in the media?

**Tim:** I think people love to hate them, which is sort of sad to me as well. I think that, like anything in the ocean, it's not on our radar a lot. Once we move off of land into the sea, it's quite

literally another world, and when you move from the shallow seas into the deep sea, it's like outer space. *[Alie laughs]* I think that, as humans, we tend to look at things that have features that are similar to ours. If they have big eyes, they're cute, you know, we look for those features, and I think hagfish pretty much lack everything that we can associate with. *[both laugh]* That probably lends it to seeming like an ugly worm-like, eel-like creature, but I'd say that the more you work with them the cuter they become, and your respect level definitely goes up.

**Alie:** Do you have favorite hagfish in the tank? Are you like, "What's up buddy?"

**Tim:** I think so! They do have different skin features, just like we do, that you can use to identify individuals and I also think that they have personality, that some are naturally more relaxed than others. Depending on what you're wanting to do with them, you know, a relaxed hagfish can be a good hagfish. *[laughs]*

**Alie:** *[laughs]* I wonder if the other hagfish are like, "Why does he always get picked?" and he's like, "I don't know man. I'm just cool to kick it with." *[both laugh]*

**Aside:** Just an update, my new life motto is: *[Tim's voice with a radio style filter]* 'A relaxed hagfish can be a good hagfish.' Also, Tim says hagfish DO have a reason to be uptight - scientists aren't sure what effect overfishing or rising ocean temperatures will have on their populations. Plastic is, of course, another issue. Tim says we all know it's on the surfaces of the ocean, but he wonders where it's ending up in the deep sea as well, and what organisms are ingesting it, and what that'll mean for the future of the hagfish. He's about to embark on an expedition to the Galapagos. He's great at trapping and is tinkering with new observation cameras to deploy. Folks on his research team refer to him as the hagfish wrangler.

**Alie:** How deep are you able to do research?

**Tim:** I think a lot of the limitations are because... Say if we're dropping traps, you typically will have a rope that has to go the whole depth, if you're in 4,000 feet, you need such a huge amount of rope to get down there that it limits how many traps you can have down at once. We're experimenting with some lineless trapping methods that actually use corrodible links that are made of magnesium, that corrode in seawater at a known rate, so that you can drop traps and our camera equipment into, say, like 6,000 feet of water and have them float back to the surface once the link corrodes. There are some really unique deep-sea technologies that are making this stuff possible now that maybe wasn't ten to twenty years ago. This is all a start. It's just ramping up! *[laughs]*

**Alie:** Yeah, such an exciting field of research, I feel like so many eyes are on hagfish, to be like, "What is happening with hagfish? Where is the slime coming from? How have they lived for so long?"

**Aside:** Quick check in; I searched 'hagfish myths' and I did see that Google auto-filled with the most frequent questions asked which included: "Are hagfish poisonous?" WHAT? No. "Can a hagfish bite a human?" No, they don't even have a jaw! However, if you wound up on the ocean floor, not alive, it might smell you, find you, munch you, poop you, spread you. But at that point you would have bigger problems than the hagfish.

Now, I kept searching for more flimflam and found that in Korea, hagfish is an aphrodisiac and a fertility food; its shape might have something to do with that. I also came upon a *Smithsonian* article that said, "According to common hagfish mythology, they can fill a 5-gallon bucket with the stuff in mere minutes," and that is a myth! Because, people, it takes SECONDS and it would be a barrel!

**Alie:** Is there any flimflam about hagfish that you would want to debunk? Any myths that you feel need to [*dismissive clicking sound with mouth*]?

**Tim:** Oh, hagfish myths? You should throw in my way. What have you heard? What are they up to?

**Alie:** Oh, I haven't heard... I haven't heard a lot of faulty gossip about hagfish.

**Tim:** Yeah. [*laughs*]

**Alie:** Maybe, I mean, they're opportunists – that's the beauty of them – but do you think people are grossed out by them because of the m\* [*ding*] factor?

**Tim:** Oh, I think so, yeah. I would say that really grosses people out, but the reality is like the m\* [*ding*] and the slime itself is not sticky. It's not toxic. It's actually really fun to play with.

**Alie:** It is! I would say that.

**Tim:** You know, I would challenge anyone to meet a hagfish, and to see their slime, and not be as intrigued as I am. Right? You are sometimes literally left speechless and in wonder.

**Alie:** Yes! Have you ever seen any hagfish in a movie or a TV show?

**Tim:** I think there have been some hagfish cartoons. There was a band called Hagfish! It was like a punk band called Hagfish.

**Alie:** Really?! What'd you think of 'em?

**Tim:** I've never listened to them... I should! [*laughs*]

**Alie:** It's gonna to come up on their Google alerts, they are going to be like, "Oh man, that's about the fish again."

**Tim:** [*laughs*] Yeah.

**Aside:** The band Hagfish emerged in 1991, broke up in 2001 and had an energetic neo-punk style descended from the Descendants. Now, one of their most revered studio albums is called *Rocks Your Lame Ass*, and according to music journalist Trixie Delight, their name itself means nothing to the band personally, it was simply chosen randomly from a dictionary. [*clip of the band, Hagfish*]

P.S. They wore suits and had sideburns and opened for Reverend Horton Heat and made a few other albums. So, Hagfish kinda made it big. But how big can hagfish make it?

**Tim:** You know, we're already seeing, some of these hagfish are four to six feet long, others are absolutely tiny, 10 centimeters. I'm sorry, I keep jumping between the two systems.

**Alie:** [*laughs*] But we just don't know how old they get?

**Tim:** No.

**Alie:** Because nothing calcifies, there's nothing to... [*gasps*] They're such a mystery.

**Tim:** That's one of those things, a lot of fish are indeterminate growers. They technically have the potential to grow forever. In the deep sea, especially with such a strong defense mechanism like the slime that they have, yeah, they could live decades! They could live over a hundred years. Who knows?

**Alie:** Wow, they're such a quiet badass. [*rock guitar riff*] That's what I love about them, they're just like, "Oh, I'm sorry. Did you want to mess with me?" It's just like, "Daaamn, hagfish!"

**Alie:** Can ask you Patreon questions? Oh my gosh. I got a lot of questions from listeners.

**Tim:** Yeah, for sure. That's good!

**Aside:** Okay so before we get to Patreon questions, a few words from sponsors of the show. They make it possible for me to give a donation each week to a charity of the ologist's choosing. This week, Tim asked that it go to his Canadian woodsy science home away from home, The Wildlife Research Station. Since its inception in 1944, the Wildlife Research Station has been providing access and logistical support for University and government researchers. It's situated on Lake Sasajewun in Algonquin Provincial Park and operates as a non-for-profit organization. It has been instrumental in these really uniquely long-running research projects on wildlife, from flies, to small mammals, turtles, birds, and more. A link to that nonprofit will be in the show notes and up at [AlieWard.com/Ologies/Hagfishology](http://AlieWard.com/Ologies/Hagfishology).

**Aside:** This first question was also asked by patron Shea Goddard.

**Alie:** Sydney Brown wants to know: Where did hagfish get their name, and what's the biggest hagfish ever found?

**Tim:** That's a good question. In terms of the word hagfish, I'm not sure, but obviously if I were to take a more of a random guess at it, it has something to do with their looks. I'm just going to go ahead and guess.

**Aside:** Side note patron Carla Kennedy asked: Are we sure they were supposed to be named "hag" and not "gag" fish?? Typos happen. Shrug emoji.

Wow. Wow Carla. Where is the respect for a slimy jawless sausage with a tiny dick mustache?

I'm sorry I made everyone wait this far to hear the etymology of hagfish but, okay: The term was first recorded in 1611 and is just comes from their face. Because they thought they were not cute. Sometimes the most obvious answer is, insultingly, the right one. But, though now hag technically means 'a repulsive old woman' according to the dictionary, that word is derived from the word for witch, which, given the magic spell it can cast in the form of a phlegm net, isn't so off-base. And the reason why that word meant 'witch', that became the word hag, is because it came from a term for a hedge rider, as in, a supernatural woman who rode the hedges between the safe, normal village and the wild outer lands.

So, hagfish: spellbinding, rule breaking, living in the darkness, and making alchemy of a whale carcass and turning into magic nutrient poo. Now, on the topic of kalology and how women are judged by toxic beauty standards, a few people including Amber and Jonathan Meade as well as Kelsie Libbu, Francina Martinez, Megan Metcalf, Jessica Beard, Amanda

Blackburn, Hannah Lise, Kimberly Fajardo, Katie Kelly-Hankin, Dominika Dec, and Trent Hoppe, asked this next one.

**Alie:** Amber and Jonathan Meade want to know: Are there any medical or cosmetic uses for hagfish slime?

**Tim:** I think there's definitely an interest in the cosmetic field, as well as in the medical field, in the sense that it could maybe be used as a biological filter. If it blocks the flow of water and traps water, you can maybe use it as an actual filter material. There's interest in using it as a food product as well, as an egg replacement. I've seen hagfish slime itself turn up in recipes. I think that there's... People, for a long time have been looking to use it for different things. I think partially what's limited it is the availability of hagfish. They're just not super common on land. *[laughs]*

As well, it's difficult to store the slime, so the way that the hagfish stores it inside of their glands is not really well understood. We know the chemicals that are there, we know (sort of) the environmental conditions inside the gland, but how they function is not really well known, and we've had a hard time replicating it. I think that's another one of the challenges to mainstream use of hagfish material, is that you need to be able to maintain its really charismatic properties over time. *["You're one of the most charismatic people I've ever met!"]* We see that its reactivity to sea water, the rate at which it responds, and everything changes as we store it.

**Alie:** What happens if you have a mason jar full of hagfish slime?

**Tim:** It eventually, if it's in water, will collapse. The network does collapse down and it essentially will somewhat dissolve away. The m\* *[ding]* component is dissolvable, but we've never followed it over really long periods, like days or weeks. Typically for most of our work we're interested in the really short timescale stuff. If we were to use hagfish slime for medical purposes, or cosmetic, or anything, we need to either figure out how to replicate it or how to store it in really meaningful ways.

**Alie:** I feel like if you had a sheet mask that was just hagfish slime, that would be hydrating as hell. Can you imagine? Just get a hagfish to lay on your face. I mean, that's essentially what a sheet mask is.

Cullen Elijah wants to know: Where do they fall in the food chain? Do other animals want to even eat something that slimy? If you're a mammal, a sea mammal, you can chomp on it, but where do they fall in the food chain?

**Tim:** I wouldn't say that they form the bottom of the food chain, but I wouldn't say that they're necessarily the top either. There's a lot of really active predators, even in the deep. There's big, active, shark species, there's big fish species that would probably be the dominant predator down there. They have such a strong defense mechanism... which could also be viewed as sort of a competitive thing. As they're feeding at a carcass they do release bits of slime. That has sort of been one of my ideas too: Whether or not they actually use it to compete around a carcass. Hagfish can all deal with the slime, but nothing else can. Now, in terms of where they fall; they are preyed upon, but they're also a predator, so I think they're going to be somewhere in the middle, in terms of the zones of animals out there.



**Alie:** Ooh. I love that they're like, "Hagfish party only."

**Aside:** Okay so Chris Brewer asked this next one, but so did Jack, Amanda Nyren, Lani Bouwer, Sonya Karpelevitch, Bonnie Joyce, Amelia Blakeman, Kitti Halverson, Vaughn Svendsen, Zoe Jane, Hayley Everson, Erik Pohanka, Danni Q and Shellina all asked some form of this hungry question.

**Alie:** Chris Brewer wants to know: Will hagfish sushi ever trend?

**Tim:** Ooh, well hagfish are eaten in Korea and probably elsewhere and Southeast Asia. They're barbecued, typically.

**Alie:** Okay. Have you ever eaten it?

**Tim:** I have never eaten it. I think the more time you spend with stuff, the more you sense its distinct smell and the more that it would probably taste like the smell. [*laughs*]

**Alie:** Erik Pohanka wants to know: Have you ever tried eating their slime?

**Tim:** No, but I know people have and that it is a part of recipes as an egg replacement. But again, I don't think the slime would taste like much. It probably tastes like seawater.

**Alie:** Does it do the same thing in freshwater?

**Tim:** Less vigorously.

**Alie:** Really? So, what is it about the salinity that activates those threads?

**Tim:** Well, that's one of the things that we're trying to figure out, like, whether it's active exchanges that go on with ions associated with the  $m^*$  [*ding*] or the threads, whether it's a temperature-related thing, like the slime tends to set up better in cold water than warm water. It's a fairly complex problem, I guess. We've been going at it from a lot of different angles and we have a fairly good idea of the parameters that result in good slime formation, but the actual chemical basis for it all is still out there.

**Alie:** Which is so exciting! Is it exciting to be at the forefront of this research?

**Tim:** It's super interesting. Everything we do day-to-day, for the most part, has never been done, so that gets me excited.

**Aside:** Heads up, spoiler alert! This next question may deal with non-Newtonian fluids, so I thought I'd drop a def here now. I'm going to read this part right off of Wikipedia, because I didn't want to get it wrong:

*A non-Newtonian fluid is a fluid that does not follow Newton's law of viscosity. In non-Newtonian fluids, viscosity can change when under force, to be either more liquid or it can be more solid.*

So ketchup, for example, becomes runnier when it's shaken, thus ketchup is a non-Newtonian fluid. I just learned that right now! It also says custard, honey, toothpaste, paint, blood, and shampoo are all non-Newtonian fluids. It all sounds just like a delicious smoothie. Just toss 'em all in a blender.

**Alie:** Sarah wants to know: Is hagfish slime a solid or liquid? Is it a non-Newtonian fluid?

**Tim:** It is a non-Newtonian fluid. So, hagfish slime does have solid components to it, but because it essentially... We call it viscous entrapment; hagfish slime doesn't bind to water at all, it essentially creates channels that are really narrow, that work on the surface tension of water to trap it and slow its flow. It essentially slows water flow to a point that it creates the slime, but if you hold that slime out of water, all that water will drip out eventually and you'll be left with nothing but a bit of m\* [*ding*] and fiber.

**Alie:** Oh my gosh. So, it's kind of like a really good net for water?

**Tim:** Exactly. Which is sort of why earlier I said it'd be interesting to apply it to something like an oil spill and see how it worked at mopping up the water with the oil component in it.

**Alie:** Oh my gosh, that's so fascinating! Lara Taffer wants to know: Do hagfish have any close relatives to any land animals?

**Tim:** Land animals? I don't think so. Their closest relative that still living is the lamprey. They're sort of grouped together with hagfish because they're a jawless creature, they have a primitive eel-like body, but I think the jury's out about whether or not hagfish actually started out much more vertebrate-like, and then lost those vertebrate-like features, so that what we're seeing is essentially something that was more complex that was actually somewhat simplified in time.

**Alie:** They may have just gone on back? That's fascinating. Suki Hawley wants to know: Since hagfish are creatures of the deep, do they get the bends when scientists bring them up to the lab to study?

**Tim:** It's a super good question. A lot of fish have what's called an air bladder, which actually fills with air to provide buoyancy for them, so they can fill it and empty it to adjust where they are in the water column. Hagfish don't have an air bladder, so when we bring them up, they're actually totally fine. It's a good question, because most fish that you would bring up from that depth are dead by the time they hit the surface because their swim bladder actually ruptures and causes severe damage to the fish itself. Hagfish don't have that problem, which is one of the reasons we can even study them. Hagfish seemingly have no problem coming to ambient pressure at the surface.

**Alie:** There's such slimy bad asses. I'm voting for Hagfish for president, is that weird? [*Tim laughs*] I'm so in awe of them. I feel like hagfish is gonna absolutely save the world. Okay. I'm going to ask one more question from a patron and then we'll wrap up. Travis DeMello wants to know: What are their social lives like? Do they relate to one another, and where do they sleep?

**Tim:** I think that's another great question. I think hagfish have very vibrant social life. [*"I got lots of friends."*] We see them living in burrows together, we don't know about their relationship to each other, but they seem to like to pack together. They do like to be together in congregations. Where you find one hagfish, you find more. Whether or not that has to do with the environment being really conducive to hagfish, or whether or not they actually seek out a social group, we don't know.

We're actually working on at least filming them in captivity to better understand how they interact with each other over the days and weeks of circling around these tanks, and with

very limited hiding spots. We provide them with habitat to hide in, but we're interested in how they compete for that habitat. Like, are there dominant hagfish and subordinate hagfish? Or are they sort of devoid of that altogether, which is also a possibility, that the whole competition that we see in a lot of other animals may be such an energy waster for a hagfish that they just don't do it.

**Alie:** Aww! Just, maybe they don't care?

**Tim:** Yeah. Maybe hagfish are friendly. *[laughs]*

**Alie:** Is there a need for more hagfishologists?

**Tim:** I think there is a need for a lot more people to study what's happening in the oceans. In many ways, Antarctica and Space are these like crazy frontiers... I think the deep ocean is one of the last unexplored frontiers on the planet. A lot of these missions that have gone down to video find new species. Almost every time they deploy these ROVs or deep-sea submersibles, they find new species.

I know that we get very excited when undergraduates come into the lab and we get to introduce them to hagfish and spread the wonder, for sure. But I think that it is one of those things that... Most biologists that ever come across them are permanently interested. They never lose their interest. And we've seen this with the people that are now in their 90s that love talking hagfish because they maybe worked with them for one year, decades and decades and decades ago, but it was when the most interesting things they ever did.

**Alie:** You just get caught in a slimy web of love for hagfish.

**Tim:** *[laughing]* All of the puns. Yeah.

**Alie:** I always ask this at the very end; is there something about your job that sucks? Something that frustrates you? What's the worst part about your job or hagfish?

**Tim:** I think... Nothing wrong with the hagfish, but I think in terms of science in general, there's a lot of failure. When you're doing projects, you're doing experiments in science, you never know what's right. You'll only ever find out what's likely wrong. I think that would be the most frustrating thing, is that you have to have pretty thick skin, in a way, to deal with it. Especially going up against questions or developing experiments and apparatus that have maybe never been used or designed before. There's no *Hagfish 101* book that we can turn to, to figure some stuff out. There's a good body of literature on hagfish. We do have what we consider the Hagfish Bible, it's called the *Biology of Hagfish*, and there's been, I think, three iterations of it now.

**Alie:** Do you have a copy in your glove compartment, one at home, one at work? *[laughs]*

**Tim:** Oh yeah, I've got one here for you. *[laughs]*

**Alie:** The pocket guide to hagfish...

**Aside:** I texted Tim later and asked, "What was the Hagfish bible?" and he said there are two: *The Biology of Hagfish* and *Hagfish Biology*. I hope the authors are friends.

**Tim:** I'd say that's it, but I think that's part of the fun too. I'd say the primary frustration is also the primary driver. *[laughs]*

**Alie:** What is your favorite thing about your job? What's your favorite thing about hagfish, or your job, or what you do?

**Tim:** I think that it's discovery. I think it's like you were saying earlier, it's being on the forefront of something. It's literally looking into the abyss. Like, how did natural selection act upon this? What does this mean in terms of how hagfish relate to each other? How did they relate to vertebrates and other fish? And I think that that's something that just keeps us endlessly intrigued because there are more unanswered questions than answered questions, and I think that's good for any scientific field. You want to think you have a good idea of what's going on, but the more you know, the more you know you don't know. Right? I think that's a good problem that scientists have.

**Alie:** And so that keeps you going a lot?

**Tim:** Oh yeah. For sure.

**Alie:** Oh, great. Thank you so much for doing this, I'm just so charmed by hagfish.

**Tim:** Thank you, that's awesome. *[laughs]*

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So, remember to ask smart people real stupid, gross questions because how else in the world would you discover that hagfishes are handsome drifters, and 17th century witches, who live in a timeshare with Bigfoot and the Holy grail and help impotent men have a long-awaited child and deserve our respect? Some of those may not be true, but they are an inspiration for military defense, they could change the way we use fibers, they're pretty chill, and yes, they deserve our respect.

Now Tim Winegart is not on social media – God bless this Canadian hagfishologist – but you can google the [Douglas Fudge Lab](#) at Chapman University to learn more about what they're researching; so many great resources! We're @ologies on [Twitter](#) and [Instagram](#), I'm [@AlieWard](#) on [both](#), and are links are in the show notes, and they're up at [AlieWard.com/Ologies/Hagfishology](#). You can get merch through that site or through [OlogiesMerch.com](#).

Thank you to Shannon Feltus and Boni Dutch for managing all that. Thank you Hannah Lipow and Erin Talbert for adminning the wonderful [Facebook group](#), to interns Hari Kim and Caleb Patton, to Jarret Sleeper of MindJam Media for assistant editing, and of course, to the mysterious slime witch Steven Ray Morris who edits all the pieces together and also hosts the kitty podcast *Purrrrcast* and the dino-centric *See Jurassic Right*. The theme song was written by Nick Thorburn of the band Islands. He also did the theme song for *Serial*. Fun trivia.

Also, before the secret, I wanna say a quick belated Happy Birthday to my dear friend Mika, also Happy Birthday to Steven Ray Morris, who's birthday is on Wednesday of this week. Happy Birthday to Katherine Burns who has a birthday this week also to my niece Olivia. Happy Birthday to boob-haver, bra buyer, good friend Coleen whose birthday is this week. So many April birthdays. I love you all.

Now if you stick around until the end of the episode you know I tell you a secret, and this one is pretty straight forward. It's pretty topical. The reason that I took the lab tour and you didn't hear it is because there is ONE button that I accidentally pressed on my Zoom, and it switched over the

mics so that the onboard mics weren't picking anything up. So, it was just 32 minutes of static. Boom! I'm sorry! Bummer! Great episode anyway.

Another secret is that I had a dream that I had a livestream and no one showed up to watch it, and I was wearing, like, dirty grease-spotted leggings that were made by Ferrari and I was like, "Uhhh, these are my good leggings. I really messed these up." Anyway, no one watched my live stream and I thought, "Ward, what are you doing! Nobody wants this stuff." Anyway, I woke up and was like, "Well... At least Ferrari doesn't make leggings."

Okay, berbye.

*Transcribed by Colette Ayers, London, England. If you're a Hagfish, I'm a Hagfish*

**Links which you may enjoy:**

["Hagfishology" is a word, okay?](#)

[Fun facts about hagfish](#)

[The band Hagfish: probably less slimy?](#)

[Ed Yong's wonderful hagfish article](#)

["It was liquid eel" CBS News video footage](#)

[M\\*cus so soft tho: a study](#)

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