Supplementary materials

Student Transcripts

Participant A: Item 1

Interviewer: …how would biologists explain how a living opossum species without a tail evolved from an ancestral opossum species that had a tail?

Participant A: Um, hold on, well it could also, it could be the bottleneck effect or the founder's effect, like, the ancestor species could have had like a nat-, disaster, like a, calamity, so only a few of the, uh, individuals survived and those individuals like maybe had like a dwarf gene, or like a, like a gimp tail I guess. And then eventually it started being more prevalent in the, in the new species that started from there. Or, just, um, reproductive success…

Interviewer: …And you talked about how, uh, back with this bottleneck effect or this founder effect

Participant A: Mm hm.

Interviewer: That there were individual, a few individuals that had a, a dwarf tail or, um, gimp tail…

Participant A: …Yeah.

Interviewer: Um, how did that, how did they have that tail, or how did they get that different tail?

Participant A: Um, maybe like survivors from the calamity had like some, uh, maybe they did, maybe they didn't, like they could have expressed that gene in like, uh, um, uh, in

like a repressed way, than having like a full on gene or maybe they had the full gene and then, like, eventually, wait can you repeat your question? Sorry.

(general confusion and then Participant A provides an adaptive reason)

Participant B: Item 1

Interviewer: Question one, how would biologists explain how a living opossum species without a tail evolved from an ancestral opossum species that had a tail?

Participant B: Um, it could be a couple things I guess. Either the opossums with the shorter tails, or something like that, were more suited to their environment and then it just kept getting shorter and shorter. Or, um, if there were opossums with shorter tails and something happened to like bottleneck them or something, and it didn't have, uh, an advantage or disadvantage they could just go away randomly.

Interviewer: Can you explain what a bottleneck, um, is?

Participant B: Uh, yeah, if something happens and a good percentage of the, uh, individuals in the species or population dies or gets separated or anything like that, the small amount that's left would be the bottleneck.

Interviewer: And can you explain how the, um, lack of a tail came about to begin with?

Participant B: Um…what do you mean?

Interviewer: Cause you said that there were, um, individuals with…

Participant B: Oh, yeah, I was just saying like maybe some had shorter tails, and some had longer tails and then eventually if like the shorter ones lived, or were more successful, and shorter tails or no tails were more advantageous in the environment then eventually it could just keep selecting for shorter and shorter tails.

Interviewer: And what do you mean by selecting…they were selecting?

Participant B: Um, like if shorter tails did, were more successful in the environment, they would have a better chance of living and passing on their genetic information.

Interviewer: So who what would be doing the selecting in that scenario?

Participant B: The environment.

Interviewer: So in that ancestral population what you're saying is that there were there are some individuals with tails, some with short tails, some without tails?

Participant B: Yeah…

Interviewer: …So there's some variation?

Participant B: Yeah…

Interviewer: Okay

Participant B: … Or I guess there could be a mutation and that animal did fine or better.

Interviewer: Would it be the same kind of situation for the bottleneck where there's variation in the ancestral population or a mutation?

Participant B: Yeah, and then, like, it could be possible that more with shorter tails lived through the bottleneck just randomly, just by chance, and then it would be, I don't know, I don't know what I'm trying to say.

Interviewer: Anything else you want to add to that answer?

Participant B: I don't think so.

Participant C: Item 1

Interviewer: In that first question, um, just kind of backtracking, you said that the tail, or the lack of a tail would either have no effect or be advantageous. Can you tell me more about, um, the situation in which it would have no effect?

Participant C: Um, if it had no effect it would just, they would just be living, I mean they would just be there, and some would have tails and some wouldn't. But if it was advantageous, then it would probably be a selection pressure to have them, uh, to not have tails, but, that's it.

Interviewer: If it had no effect could it still lead to, um, the species not having a tail or no?

Participant C: Yeah.

Interviewer: Ok, can you talk about how that might happen?

Participant C: Uh, something like founder's effect.

Interviewer: Ok, what's founder's effect?

Participant C: Um, it's like when, uh, part of the population gets isolated and, uh, um, it's like alleles get uh, a rare allele becomes dominant.

Interviewer: So in that way, the tail, the lack of a tail might become dominant, or no?

Participant C: Yeah.

Participant D: Item 3

Interviewer: Ok, question 3, how would biologists explain how a living lily species without petals evolved from an ancestral lily species that had petals?

Participant D: Ok, species without petals evolved from an ancestral lily species that had petals. Ok, I mean, I just thought of something I could have said for the other ones, that there could have been some kind of catastrophe of some sort that narrowed the uh, but I guess there would have to be some species that had, already had like little petals, like reduced petals through like, I guess, a mutation or some variation, but that, so that could have eventually become more prevalent as we said before through it being favored in the environment, or there could have been some sort of, uh, like environmental catastrophe that killed most of the species and left the few species that survived with, or the ones that survived had that mutation for reduced petals so they eventually became the prevalent species. Um, I guess that would be a founder effect I think, or a bottleneck. Um, so the species without petals not necessarily that it was favored but because it was in greater variety or greater, uh, it was in greater number than the ones without, that had the larger petals, it eventually, uh, I guess it was eventually derived to a species without petals, in the living species today.

Interviewer: So the ones, um, without petals were more numerous, is that what…

Participant D: …The ones without petals became more numerous.

Interviewer: Ok, they became more numerous.

Participant D: Mh-hm.

Interviewer: At what point, when…

Participant D: If there was that, I guess, bottleneck, or if uh, or over a long long or I guess they'd both be over a very long period of time, that the mutation was somewhat favored in the environment to have reduced petals so eventually they became more reduced, reduced and reduced and reduced until they didn't have petals.

Interviewer: Ok.

Participant D: Over a very long period of time.

Participant D: Item 4

Participant D: …Um, I can't see what else, uh, or I guess there could be some sort of bottleneck as I said before for the other one, that could also, will explain how the spines first became favored, but I mean, overall it'd most likely be that the mutated species, or the first species to develop somewhat of a spine would be favored because it protected it more from, one without.

Interviewer: Can you, um, explain how the individuals with that variation got that variation?

Participant D: Uh, through some sort of, I guess, mutation or some sort, like maybe it uh, there had to be one that first had somewhat, like maybe a leaf, and it developed from, I don't know how, I know it did, but uh, some modified, I think a spine's a modified leaf, so, first species, um, so there would have been a change in the leaf. Um, I guess all I can think of is through a mutation or through, uh, some kind of change in the genotype of the leaf that would make it appear differently than a typical leaf. Maybe just by some small, some small, uh, like some small difference I guess, and that would be favored so that would eventually lead, eventually to the spines developing over time in different species.

Participant E: Item 4

Interviewer: Question 4, how would biologists explain how a living cactus species with spines evolved from an ancestral cactus species that lacked spines?

Participant E: I guess that could be similar with either, like a genetic mutation or maybe a genetic drift and, uh, just, could also have to do with, uh, like being an anti-predatory defense to, uh, protect it since it's in a harsh environment already, they kinda have to guard themselves from anything that's going to get water out of them.

Interviewer: You said that it could be a genetic mutation or genetic drift, can you explain what you mean by genetic drift?

Participant E: I always forget the definition of genetic drift. Um, it's kinda just like, uh, a swing towards one extreme instead of where it was before, but I guess, so I guess that kind of takes away from what I was going towards, I guess, kinda contradicted myself.

Interviewer: What's swinging? What is that is swinging towards one extreme?

Participant E: Uh, just kinda like, the genetic makeup or the, uh, actual structures that are present are kinda more of a shift from one to another based on the pressures that they're getting from the environment or from, from other species around them.

Interviewer: When you say structures, do you mean, um, what do you mean by that?

Participant E: Um, sorta like the actual spines, in this case, or uh, the the cells within, that are used to maintain the water and the moisture and hold it.

Interviewer: And how, how does that process of swinging towards one of the extremes or another come about?

Participant E: Um, I guess that would be more, type of a, kind of, more of natural selection, where they're, where if they don't change then they're just going to die out, so without, if the, if they didn't develop the spines, there'd be no way for them to completely protect themselves, they would, without spines they'd probably evolved in another way and came up with some sort of poison or something else that would have deterred predators and stuff from eating them.

Participant F: Item 1

Interviewer: …how would biologists explain how a living opossum species without a tail evolved from an ancestral opossum species that had a tail?

Participant F: Um, well biologists would probably just use, like, the natural selection-type aspect of it, um, where over a period of time the allele frequencies changed, um, where, the opossum species, ancestral opossum species that had a tail, um, over time, um, they either, the tail, by mutation either was shortened, um, and that was like, something

that was advantageous to where, um, they, um, were the ones that were doing most of the reproducing, or, um, like a bottleneck type of thing, where, uh, like a population of shorter-tailed or no-tailed opossums, um, were completely separated by some type of natural event, um, from the other group and the other group tended, it like ended up going extinct, while, um, the opossum species without a tail continued to live and evolve, um, and that type of thing.

Interviewer: Um, when you talk about the mutation happening is that happening in the species?

Participant F: It'd be happening at an individual level but it'd have to happen, um, like it'd have to be something that can be, um, given and inherited to the next generation, so over time, the whole population, um, is given that mutation. Like so it takes a really long time to do.

Interviewer: Ok. And you talked about that trait being advantageous in terms of reproduction…

Participant F: … In terms of, um, yeah, the overall fitness of the, um, animal. So, their ability to survive, at least until reproductive, reproductive age and then to, um, reproduce…

Interviewer: Ok.

Participant F: …give it to their next person.

Interviewer: And with that event that you are talking about, the bottleneck - is that what you said?

Participant F: Um hm.

Interviewer: Um, so that involved them being, a portion being separated?

Participant F: Yeah, like there's the founder effect, um, where, like a portion of like, I don't know, they always use the, an animal is, like, on a log and it floats to a different island and then it's a new species on that island, so it's like a group of animals, um, on that island, that are completely separated from another, or um, and so they're like favorable whereas the other ones like a natural disaster could happen at like, where their home was, and they are able to, like, evolve on their island, or like, um, if they're all in one place, and um, like a few are off somewhere else and like a huge natural disaster like a meteorite shower or something happens at their home place and they're like far away, and even if they come back to the same place, they are like the only ones living, so it's like, it could happen by just random chance, it's not necessarily genetic. And that causes them to lose their tails.

Participant F: Item 3

Participant F: …so it'd be, like, natural selection again, um, either by mutation or, um, like genetic drift, some type of, something like that, like over time it was more advantageous for lily species, the lilies without petals to have…

Interviewer: So in this scenario it could be natural selection or genetic drift?

Participant F: Um hm.

Interviewer: Um, but either way it involves the trait being advantageous, or no?

Participant F: It, like, overall it has to be advantageous. It might be like, at the time it might not seem fully advantageous to the plant, but like, in regards to, like, it's ability to survive, and, um, like reproduce, it increases their chances of doing so, so yeah I would include, like it could be like a mutation or natural selection or genetic drift.

Participant F: Item 4

Interviewer: So you started off at the very beginning talking about, um, it could happen through natural selection, mutation or genetic drift…

Participant F: …Yeah.

Interviewer: Um, can you talk more about the process of genetic drift in this scenario?

Participant F: I guess with genetic drift what would happen is, um, like a random grouping of like, let's say out of a hundred only four of these just happen to have, like, this mutation, um, that was passed down from one of their parents, and, um, they just like over time, um, they were the ones that were doing more of the reproducing or maybe just by chance that they were the ones, that like their offspring were the ones that were surviving, um, so over time, like, their genes were the ones that were being passed down randomly, um, into the population, and it just happened to be that as time went on, it was their genes that caused the population, like, not really caused the population but, um, is what the population formed into.

Participant G: Item 1

Participant G: …another way would be more like genetic drift oriented, where, the presence or absence of a tail doesn't matter very much. So, maybe it has no fitness ramifications in survivability and it just kinda fluctuates based on just randomness, you know, statistics, until eventually you've got all the opossums don't have tails. That sort of random stuff does happen, sometimes, and it brings genes towards fixture that way. But, I would say, cause it, I would say most biologists would go with either natural selection or gene drift to explain the loss of tail over time in opossums.

Interviewer: So when you're talking about the gene drift option, um, in that scenario, there would be no selection or there would be selection or…

Participant G: There'd be no selection in like a more random gene drift. That would be, you know, in whatever scenario these opossums are living in the presence or absence of a tail has absolutely no impact on survivability, but the variation still exists. So, you know, due to, you know, maybe one opossum got lucky and found a lot of females in a small population or, you know, it just happened. Or maybe there was like, a tornado, that came and killed a bunch of opossums that had tails or any other number or random, uncontrollable events that don't really have anything to do with the tail or lack of tail giving some sort of selective advantage. I mean, that's how most, like, you're flipping a coin just to see which one comes out on top. Or lots and lots of coins. Thousands and thousands of times.

Interviewer: So would you describe, um, the alternative, so we have the two options, the gene drift or the selection option, and gene drift you say is completely random, would selection be random or no?

Participant G: Selection would not be random.

Interviewer: Ok.

Participant G: Selection would be you've got some sort of reproductive advantage given by the lack of tail and that's to the point where it's, I mean, you could predict which opossums would do better and which opossums would do worse due to the presence or absence of the tail. So that's like, there's a, you know, like one thing I could think of would be opossums have a naked tail and in colder climates that could be a great way to lose heat, so maybe, you know, these opossums are living in a cold part of the world

and all the opossums that have this large exposed naked tail lose a bunch of energy because they're not insulated and the opossums that don't have a tail save that energy and put it into reproduction or offspring or whatever and they end up coming out with better results. So that's less ran-, that's not random, that's, you know, it's predictable, and there's, like, the natural selection, you know, force, that's kinda acting on it. Where there's like a quantifiable difference in the fitness, and like the vitality and viability of the gene.

Participant G: Item 2

Interviewer: …how would biologists explain how a living snail species with teeth evolved from an ancestral snail species that lacked teeth?

Participant G: So this one would happen in a very similar way. A biologist would, you know, you've got your random genetic drift option where there was variation in the presence or absence of teeth in the first species, and then randomly, you know, maybe due to natural disasters, or just certain members got lucky in breeding, you'd have the fixture of the lack, or the presence of teeth. And then you'd also have the possibility of a natural selective-based theory where the presence of teeth gave some sort of reproductive advantage to those snails. So, that gene moved towards fixture…

Participant G: Item 3

Interviewer: Question three, how would biologists explain how a living lily species without petals evolved from an ancestral lily species that had petals?

Participant G: Well, third round, uh, you've got, I would say most biologists would go to one of two possible explanations for this. You'd have a natural selection-based one or a genetic drift-based one. And both of these assume that there's variation in the population, so, you know, there are genes that code for lilies with petals and genes

that code for lilies without petals within the original species and one of them, let's see what'd I say, it's without, yeah, so for some reason, either random chance due to genetic drift, you know, maybe there's a natural disaster or something that killed all of the lilies with petals, the lilies without petals kind of became more prominent and hit fixture, gene fixture, which is when that gene becomes the only gene or a vast, you know, 99% of the genes, or there was some sort of selective agent where not having petals helped those lilies reproduce more efficiently and better than the lilies that had them. And you'd have a number of possible ecological situations that could produce that circumstance. So maybe it's the pollinating insect can get to the sex organs better if there aren't petals. Or maybe it has something to do with, you know, having seeds dispersed more easily because the petals aren't keeping them there…

Participant G: Item 4

Interviewer: …how would biologists explain how a living cactus species with spines evolved from an ancestral cactus species that lacked spines?

Participant G: Well most biologists would suggest that you had your ancestral cactus species that did not have any spines and within that population of cacti you had the variation, whether that variation came from mutation, or introduced genes from another species, you know, like a weird cross-cactus pollination event or something, but gene flow in that way. And once the variation got into the population it somehow, the presence of spines became more prominent and then eventually fixed within the species. And the ways, the mechanisms that it would probably go from being a minority to a majority would either be genetic drift, where it's kinda random, happenstance, you know, maybe all the cactus got wiped out by a flood, except for the guy, you know, the four cactus over there that had spines so this new group of cactus all have spines because, uh, the parent stock all had spines, or maybe it was

just kinda random and the gene went from being prominent to rare and back and forth until it reached fixture. Or you could have natural selection….

Participant H: Item 1

Interviewer: You also said through natural selection or other evolutionary processes, can you talk more about those other evolutionary processes?

Participant H: I knew I shouldn't have said that (laughs). Uh, genetic drift, I don't really, I can't really explain how that would play into it, but genetic drift would have something to do with that um, I can't really think of anything else off the top of my head.

Interviewer: Can you elaborate more on how genetic drift works or how it might differ from natural selection?

Pariticpant H: Uh…I can't really think.

Interviewer: Do you want to take a minute or so?

Participant H: Yeah.

Interviewer: Ok, there's no rush. Sometimes it's hard when you are on the spot…

Participant H: Yeah….(long pause). Maybe not so much genetic drift but just the fact that, it is, animals, I can't really think of what I need, what I'm trying to say, to be honest.

Interviewer: Feel free to like think out loud. Don't worry about whether you are coherent or not, it's fine.

Participant H: I think the way genetic drift influence it, is that through time and passing on of traits and genes, that it was affected, oh gosh, I feel like I'm rambling and I'm not really saying anything. (long pause) I can't really think of what I want to say with genetic drift.