A Fresh Look at Domestication

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Nature's Greatest Success: how plants evolved to exploit humanity, by Robert Spengler, turns the received wisdom on domestication and the invention of agriculture on its head.

So what does Spengler means by domestication?

Robert: Domestication is an evolutionary process, and cultivation is, of course, a cultural process. So cultivation in the way I use the term can refer to either plants or animals, but it is a suite of behaviours that involve humans maintaining their populations for a variety of different purposes. Domestication is often the result of that, but not always. I use domestication in a very, very broad way in the book, in that I think the definitions that most people think of with domestication have biased our interpretation. So often people say: they domesticated this. The active terminology itself makes people believe that the process is something that humans did intentionally. So I have tried to use the term domestication to refer to any kind of anthropogenically driven evolution. So any ways that humans cause evolutionary change in the organisms around them. This can be weeds in agricultural fields, it can be the plants growing up between the cracks in the sidewalk in cities, it can be the changes in cockroaches or insects in your house that have evolved to better survive in these kind of domestic situations.

Jeremy: As far as crops and livestock go, but maybe more generally, what are the key changes that you see in domestication?

Robert: Yeah. So the key early changes for ... I'll start with animals. Obviously the biggest one is docility. So lack of a fight or flight response, kind of, tolerance to being around humans. Tameness. But so, tameness is essentially the first step in this, this kind of evolved process. Usually I use the word tameness to refer to docility that is not genetically locked into place. So you can tame a wild bear, but if you were in theory to tame many, many, many generations of wild

bears, they would evolve to lack fear around humans. Key traits in plant domestication are the increase in plant mass, so the plants themselves become larger, increase in seed size, and a loss of traits associated with the seed dispersal system, and this includes a loss of dormancy. So dormancy is actually dispersal through time, so it is still a dispersal system. And there's tons of secondary domestication traits. Things like loss of defensive compounds, so chemical defences in the plants, things like bitterness which tends to be a chemical defence in the plants to protect against fungal attack, things like that. These are all things that make them more suitable for humans, but arguably are evolving away from the plants simply by humans removing the plants from herbivory pressures or insect predation, or in theory also fungal attacks as well.

Jeremy: So it's interesting, because a lot of the sort of what I would call natural speciation, Darwinian speciation, is precisely based on not interbreeding with the population you came from. So in that respect, artificial selection, natural selection, roughly the same?

Robert: Yeah. And in many ways, Darwin created a bit of a false dichotomy in separating them. But if you really read his stuff, he uses domestication as the key case study to try to convince the masses that evolution by natural selection was occurring. So he himself didn't see a strong dichotomy, despite the fact that he came up with the terminology artificial selection and natural selection. So yes, natural selection is the same essential process whether humans are doing the predation or a wild animal is doing the predation. It's still part of this natural process.

Jeremy: A lot of the examples ... In the history of thinking about domestication, one of the things they stress is the benefit to humans. It's almost like the reason for domestication is because people found it beneficial. A lot of the examples you use in response to anthropogenic change, humans don't enter into it except that they created the environment. So is benefit to humans necessarily part of your view of domestication?

Robert: It's definitely not part of my view. And I try in the book to separate the benefit to humans, or the benefit to the organisms from the actual definition of domestication that that I favour, though I will say that this is not a uniformly accepted approach across the field. Many of my colleagues would say that if it doesn't benefit humans, it's

not domesticated. But of course, this draws in all kinds of complications. Where do we draw the line between a weed in a agricultural field and a domesticated crop, if many domesticated crops evolved from weeds initially? Where do these lines draw? I like to go with a more blanket definition of domestication, and I intentionally, in the book, try to come up with many examples of evolution that humans caused, but they didn't necessarily benefit from it or ... Yeah. So one that I like to really, really harp on because it's the number one most heavily studied case study of the earliest domestication. It's the little stems at the base of a wheat or barley plant that we in the field call rachises. And these rachises in the wild state, when the wheat seed is ripe, they shatter off the plant. And it's the way the plant actually moves its seeds away from itself. So when the wind blows and the seed is ripe, the rachis shatters and the seeds move up to two metres away from the plant. So it's not a long distance, but it moves the seeds away from the parent plant.

And it has long been accepted in domestication studies that these rachis stop shattering, which is the earliest domestication trait in arguably any plant, but there's there's some exceptions to that statement. It's definitely the most heavily studied early domestication trait. And the long standing argument has been that when humans start using sickles, the process of harvesting with a sickle forces them into changing, and that humans benefited from this because it kept the seeds together on the plant. But what's really interesting is if you look at traditional wild seed harvesting practices, historically documented, they usually harvested the seeds either by beating the seeds with a stick into a basket, or by swinging the basket over the top of the the plants where the seeds are ripe. And in that case, to harvest them, you would still need the brittle rachis trait. So in that way, it actually may have been a burden for early humans that the earliest trait of evolution occurred in response to the ways that they were kind of creating these insular environments, but archaeologists have so long assumed that all these traits were actively put into the plants by humans that it was, until recently, almost impossible for them to think of the earliest domestication traits as being unwanted or undesired. And in the new way of thinking about it, humans likely developed or invented sickles in response to a domestication trait that they actually didn't want. And it's a complete reversal of the long standing argument that the brittle rachis were the undesired trait and the tough rachis were the desired trait.

Jeremy: For somebody who grew up reading Jack Harlan's experiments, where he went up the hill with a primitive sickle, harvested enough wild wheat and barley that way to to feed his little group for quite some months, it's ... It's almost heresy, not quite, because it seems so intuitive that the seeds, a lot of seeds would have fallen off, but the seeds that stuck would have been brought back to the village, would have been taken off there. And now you've got wheat plants growing up around the village. The first steps, if you like, of cultivation. What's wrong with that argument?

Robert: Yeah. Well, first of all, I'll say that Jack Harlan is definitely one of the founding scholars of the field. And if anybody's really interested in domestication studies, some of his later semi-popular books are still wonderful reads that I think kind of got brushed away with time, but I highly recommend finding them in the back shelves of the library and reading them. And one of the things, as you pointed out, that he did is a lot of experimental work. So not only did he harvest his own seeds from wild stands, which really was important in understanding how a lot of this is done. And this is one of the kind of unsung areas of scholarship in archaeology, experimental archaeology, or ethno-archaeology. So the other thing he did was the ethnoarchaeology. He went to a lot of traditional cultures around the world, especially in North Africa, and just observed how they were harvesting the wild plants. He was focused on the sickles here, but he then writes extensively about all these different cultures that harvest using a basket, swinging over the top of the field, or the beating method that I just mentioned. And then he became fixated on the sickle as the way that domestication occurred. And I think it's that latter part that kind of missed the mark. And it's not just him. He actually didn't come up with the sickle harvesting theory that was ... That existed before him, but it was so well accepted that it was almost impossible until fairly very recently for archaeologists or scholars in domestication studies to think beyond the importance of the sickle and in his case, harvesting the entire plant rather than just harvesting the seeds as they broke off.

So now we can kind of think of the process reversed. And this is coming from especially one publication by a young scholar named Maeda in collaboration with a professor at University College London, Dorian Fuller. And they simply quantified sickle blades in archaeological sites from Southwest Asia, in the Fertile Crescent area, showing that they don't become prominent in the archaeological sites

until after the fixation of the tough rachis trait. So it actually completely inverts an argument that has been so widely accepted that almost nobody even thought to question it until recently. And I think it's actually very likely that sickles were created by humans as a response to domestication occurring in these plants and humans, and domestication was occurring at such a slow rate, humans within one generation would not even have known it's happening, and the traits that were occurring actually would not have been something that humans were happy about, because obviously, if they invented a new technology to combat these traits, then they're ...

Jeremy: It's so interesting to think about because what you're saying, I think, and correct me if I'm wrong, is that the use of a basket or a stick is changing the plant's environment, and the plant is responding by developing a non-shattering rachis. Is that it?

Robert: I would actually say humans are even further removed, that it's not so ... So there's multiple levels of unconscious or unintentional evolution here. One is that the technology humans are creating is changing the environment. That's what you just said. And I think that's part of it. But I think actually it's more likely that these tough rachises are evolving because the plants are increasing in size. As the plants increase in size, the seeds increase in size, which is just a correlation. As the seeds increase in size, the mechanisms, the mechanical mechanisms for moving the seeds, in this case the rachis, the little stem itself, that shattering ability stops working because the seeds are getting too big. And these bigger stems to hold the seeds stop shattering. So it's a completely unintentional kind of cascade of changes in the plants going back to an increase in size. So the real question here in my mind is why would the plant be increasing in size?

And I think that is simply a response to the fact that humans removed the herbivory pressure. So humans removed all the animals that would normally eat these plants. And as a result, the plants have essentially changed all of their defensive structures and put everything, all their energy, into reproduction and growth. And humans completely were unaware that the plants were increasing in size. All they were doing is maintaining as as well as they could the population of plants that they used for food, and this would have simply included things such as weeding or removing competitive plants that they didn't want and moving or hunting away gazelles or wild aurochs, the progenitor for the the cow, from these landscapes.

And by doing that, there was no more selective pressures for these plants to grow smaller but more defended plants there. In losing their defences, they can then focus their energy on other things.

Jeremy: Fascinating. We talked a little bit about the benefits to humans and how maybe some of the changes were detrimental to humans. What about the benefits to the plants? I mean, bigger seeds, does that guarantee greater survival? What are the benefits to the plants of the selection that accompanies domestication?

Robert: I hesitate to personify the plants, but sometimes it's easier to colloquially talk in this way. So any parent plant should want or evolutionarily be selected for larger seeds because it results in more seed provisioning for their offspring. So the larger the seed, the quicker the seed can germinate and the faster and larger the seedling will get. And that allows it to be more competitive against other seeds, including its siblings or seeds of the same species. So if you have a relatively homogenous field of grass, the seeds that are larger will be more competitive. These seeds would continue to grow larger and larger in competition with their neighbouring seeds, unless there are things in place to stop that. And one of them is that the parent plant should theoretically want even more to move it seeds away from itself. So if the parent plant can move a seed of any size away from itself, it should hypothetically want increasingly larger seeds, or increasingly larger seeds should evolve because they are more evolutionarily selective. And I think this is largely an another unrecognised variable in domestication process in that humans, when they sow an agricultural field, what they are doing is dispersing seeds. And humans can disperse a seed of any size. So once humans become the seed dispersal mechanism for the plant, there's no reason the seeds can't continually evolve to be larger and larger.

Jeremy: The idea of humans doing the dispersal work, I mean, there's this slightly topsy turvy strand in popular writing, especially — Henry Hobhouse, Michael Pollan — that actually the plants domesticated us, and the crops that we have today would be an absolute failure if humans were out of the scene. Is that something you kind of agree with? What's your take on that?

Robert: Yeah. The question of who domesticated whom was definitely popularised by Pollan, and it's a wonderful question. It definitely forces people to rethink the entire dynamic. And I'm very

much in support of that. I'll point out quickly that it traces back to David Rindos, who I talk a lot about in the book. I think he's the founder of a lot of these ideas. But Pollan definitely popularised it or brought it into the popular domain. So I like the question in that it forces us to rethink, although the truth is neither domesticated either, because it is a co-evolutionary process and evolution is the active mechanism, neither the plant actively did anything nor did arguably, so my argument would be, nor did the human actively cause the evolution of the plant. Humans are engaged in the process, the plant is engaged in a process that results in its own evolution, but neither is obviously conscious of the process.

Jeremy: Until the last sort of 150 years or so, when we all got hold of that. So then my question is this: why has it been so attractive for scholars and others to think? I mean, is it just exceptionalism to think that humans must have done this, rather than just we were part of the system?

Robert: Yeah. And so you are correct that the last few hundred years humans actively, consciously domesticated them. That's breeding. And that is so important to recognise. And I think what you're saying here is kind of a line of thought that is all kind of wrapped up in this. So breeding plants has become so widely recognised. And we are all taught that this is how our crops were brought into being, when we were young. That to question that almost sounds to archaeologists like you are calling ancient people less intelligent. And I think the pushback on the unconscious or unintentional arguments of domestication has largely been wrapped up into a judgment that is being made here about people who cannot domesticate are somehow less intelligent. But what I'm arguing in the book is that the the idea of being able to domesticate is only a product of the European Enlightenment. It's only been around for a few hundred years, and prior to that, humans did not have a concept of evolution. They did not have a concept of being able to change an organism over time. But they did very much engage in ways to maximise yields in agricultural fields. They very much actively cultivated these plants and animals, and through that put different selective pressures on them.

Jeremy: And I suppose ... It's great, I've enjoyed talking to you, it's intellectually challenging. But what difference will it make to the future

of either agriculture or the human condition if people come round to your way of thinking of domestication?

Robert: Yeah, I think there's a lot of ways that these ideas can change our thinking in the future. One is conservation. So if we start to accept that these processes are not necessarily intentional and that they are continuing all around us today, then we can look at the archaeological record to understand the ways that humans over long periods of time have caused evolutionary changes. And this is especially the case when we think about the evolution of agricultural weeds. We can better understand the ways that humans are going to cause plants and animals to evolve to better suit anthropogenic environments in the future. And some of this is things like invasiveness in weeds or invasiveness in plants or animals. But it also, if we accept, say, the evolutionary changes are tied in with insularity pressures, humans are increasingly creating landscapes that are fragmented, that are putting these selective pressures on the plants and animals that are similar to the pressures you would get on, say, an oceanic island. And if we think of a park or a nature preserve as ecologically functioning like an oceanic island, then we can kind of use the archaeological record and ocean island ecology to kind of predict the ways that in several hundred years, or possibly even several thousand years, plants and animals will be changed through the ecological pressures that humans today are putting on them. So we think about all these pressures only affecting the short term today, but the effects that we are causing today will play out in cascading ways deep into the future.

Jeremy: So most of the domesticated plants that are part of agriculture globally were domesticated a long time ago. I mean, I don't think there's anything that's less than at least a thousand years old. There have been various theoretical accounts for why just these few plants? There's no good reason for why just these few plants. People are trying to develop completely new crops, maybe to to cope with climate change. If they take on board what you're saying, how would that change the way they're creating these new crops?

Robert: Yeah. So when agronomists try to breed new crops today, they're coming at it from the perspective that this was a conscious process, because that's how they create new crops. But if you rethink the process as taking thousands of years and that these plants were evolving without humans even being aware of it, then you would have

to rethink how to engage in the domestication process. Breeding may not necessarily get there in the same way, and this allows us to think about things such as dimorphic traits in seed or in seed dispersal systems that can easily be shifted just by changing ecologies, and not so much to try to focus on the idea that they, that we, can just as breeders today pick out any crop we want and within a short period of time cause the evolutionary changes, because that's probably not how the process played out. It was specific plants that were well adapted to landscapes that were readily changed or unpredictable landscapes, and through this, they had specific abilities already to shift certain traits. And humans stepped in and it still, even after humans change these landscapes, took thousands of years for these traits to evolve. I think there are specific plants out there that are more adapted to becoming domesticated or evolving domestication traits, and I think this is ... So I think there's been such a focus on these programmes where, say, one of the big things here is creating perennial grass crops so you don't have to resow your crops every year. It reduces erosion in the soil, all these wonderful things. But in going at this, scholars are assuming that they can breed domestication traits into any plant out there, but I think it would be much more prosperous to target specific plants that seem to be pre ... I mean, I hate the term predispositioned, but there we can use that here ... predisposition towards becoming domesticated.