

Evolution, consequences and future of plant and animal domestication

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Domestication interests us as the most momentous change in Holocene human history. Why did it operate on so few wild species, in so few geographic areas? Why did people adopt it at all, why did they adopt it when they did, and how did it spread? The answers to these questions determined the remaking of the modern world, as farmers spread at the expense of hunter-gatherers and of other farmers.

Plant and animal domestication is the most important development in the past 13,000 years of human history. It interests all of us, scientists and non-scientists alike, because it provides most of our food today, it was prerequisite to the rise of civilization, and it transformed global demography. Because domestication ultimately yielded agents of conquest (for example, guns, germs and steel) but arose in only a few areas of the world, and in certain of those areas earlier than in others, the peoples who through biogeographic luck first acquired domesticates acquired enormous advantages over other peoples and expanded. As a result of those replacements, about 88% of all humans alive today speak some language belonging to one or another of a mere seven language families confined in the early Holocene to two small areas of Eurasia that happened to become the earliest centres of domestication — the Fertile Crescent and parts of China. Through that head start, the inhabitants of those two areas spread their languages and genes over much of the rest of the world. Those localized origins of domestication ultimately explain why this international journal of science is published in an Indo-European language rather than in Basque, Swahili, Quechua or Pitjantjatjara.

Much of this review is devoted to domestication itself: its origins, the biological changes involved, its surprising restriction to so few species, the restriction of its geographic origins to so few homelands, and its subsequent geographic expansion from those homelands. I then discuss the consequences of domestication for human societies, the origins of human infectious diseases, expansions of agricultural populations, and human evolution. After posing the unresolved questions that I would most like to see answered, I conclude by speculating about possible future domestications of plants and animals, and of ourselves. By a domesticate, I mean a species bred in captivity and thereby modified from its wild ancestors in ways making it more useful to humans who control its reproduction and (in the case of animals) its food supply. Domestication is thus distinct from mere taming of wild-born animals. Hannibal's African war elephants were, and modern Asian work elephants still are, just tamed wild individuals, not individuals of a genetically distinct population born and reared in captivity.

In 1997 I summarized available information about domestication and its consequences for human history in a book¹. Since then, new details have continued to

accumulate, and unanswered questions have come into sharper focus. Sources for statements not specifically referenced will generally be found in refs 1–9.

The past of domestication

Our 'decision' to domesticate

The question "why farm?" strikes most of us modern humans as silly. Of course it is better to grow wheat and cows than to forage for roots and snails. But in reality, that perspective is flawed by hindsight. Food production could not possibly have arisen through a conscious decision, because the world's first farmers had around them no model of farming to observe, hence they could not have known that there was a goal of domestication to strive for, and could not have guessed the consequences that domestication would bring for them. If they had actually foreseen the consequences, they would surely have outlawed the first steps towards domestication, because the archaeological and ethnographic record throughout the world shows that the transition from hunting and gathering to farming eventually resulted in more work, lower adult stature, worse nutritional condition and heavier disease burdens^{10,11}. The only peoples who could make a conscious choice about becoming farmers were hunter-gatherers living adjacent to the first farming communities, and they generally disliked what they saw and rejected farming, for the good reasons just mentioned and others.

Instead, the origins of domestication involved unforeseen consequences of two sets of changes — changes in plants and animals, and changes in human behaviour. As initially recognized by Darwin¹², and elaborated by Rindos¹³, many of the differences between domestic plants and their wild ancestors evolved as consequences of wild plants being selected, gathered and brought back to camp by hunter-gatherers, while the roots of animal domestication included the ubiquitous tendency of all peoples to try to tame or manage wild animals (including such unlikely candidates as ospreys, hyenas and grizzly bears). Although humans had been manipulating wild plants and animals for a long time, hunter-gatherer behaviour began to change at the end of the Pleistocene because of increasingly unpredictable climate, decreases in big-game species that were hunters' first-choice prey, and increasing human occupation of available habitats^{14,15}. To decrease the risk of unpredictable variation in food supply, people broadened their diets (the so-called broad-spectrum revolution) to second- and third-choice foods, which included more small

