

The Development of Agriculture and Pastoralism

by Rochelle Forrester

Copyright © 2016 Rochelle Forrester

All Rights Reserved

The moral right of the author has been asserted

Anyone may reproduce all or any part of this paper without the permission of the author so long as a full acknowledgement of the source of the reproduced material is made.

e-mail rochelle.fo@xtra.co.nz

Second Edition

Published 21 October 2016

Preface

This paper was written in order to examine the order of the discoveries made during the development of agriculture and pastoralism. It is part of my efforts to put the study of social and cultural history and social change on a scientific basis capable of rational analysis and understanding. This has resulted in a hard copy book *How Change Happens: A Theory of Philosophy of History, Social Change and Cultural Evolution* and a number of websites such as <http://homepages.paradise.net.nz/rochelle.f/>, [Sense Perception and Reality](#) and [How Change Happens](#) and [How Change Happens Rochelle Forrester's Social Change, Cultural Evolution and Philosophy of History website](#). There are also papers on [Academia.edu](#), [Figshare](#), [Mendeley](#), [Vixra](#) and [Social Science Research Network](#) websites and other papers on Google docs such as [Sense Perception and Reality](#), [How Change Happens](#), [The History of Medicine](#), [The Discovery of the Atomic World and the Constituents of Matter](#) and on [Guttman Scale Analysis and its use to explain Cultural Evolution and Social Change](#) and on [Issuu](#) and [Scribd](#).

Abstract

The ultimate cause of much historical, social and cultural change is the gradual accumulation of human knowledge of the environment. Human beings use the materials in their environment, including plants and animals, to meet their needs and increased human knowledge of the plants and animals in their environment enables human needs to be met in a more efficient manner. The plants and animals in the human environment have particular properties caused by their genetic make-up and these properties make some plants and animals more suitable for domestication than others. Humans learnt which were the best plants to domesticate, and how to cultivate them, in a particular order with the easiest crops to domesticate being domesticated first and with agricultural techniques improving over time as human knowledge increased. They also learnt which animals could be domesticated and how to use and control them in a particular order with the easiest to domesticate, being domesticated first, and the harder to domesticate being domesticated later. The knowledge of how to use and control domesticated animals, improved over time, with the simplest techniques being learnt first and more complicated techniques being learnt later. The order of discovery determines the course of human social and cultural history as knowledge of new and more efficient means of meeting human needs, such as agriculture and pastoralism, results in the development of new social and ideological systems. This means human social and cultural history, has to follow a particular course, a course that

is determined by the properties of the materials, such as plants and animals, in the human environment.

The domestication of plants and animals is one of the most important events in human history. It is also one of the most controversial with much debate as to why humans began to practice agriculture and whether agriculture was a good thing. For about 95% of their existence humans were hunter-gatherers and then beginning about 10,000 years ago some humans in South West Asia began farming.

The change from hunting and gathering to farming did not take place over night. Almost certainly there was a transitional stage between hunting and gathering, and farming. This transitional stage is often called proto-agriculture. Proto-agriculture occurs when hunter-gatherers engage in practices which assist the growth of wild plants. This may involve burning off unwanted foliage to encourage re-growth, weeding, irrigation and the re-planting of plants such as wild yams after removing most of the edible part of the plant. The development of proto-agriculture reflects hunter-gatherers increasing knowledge of how to make plants grow which was eventually to lead to the knowledge required for full scale agriculture. The knowledge would have been acquired over hundreds and possibly thousands of years.

When agriculture began it would have involved a considerable time when both agriculture and hunting and gathering would have been practiced together. Eventually however in South West Asia agriculture became the primary form of subsistence. One reason for this may have been that the technologies used in agriculture would have gradually improved during the early periods of agriculture when both agriculture and hunting and gathering were practiced together. New flint bladed sickles for harvesting grains, grinding slabs to remove husks, underground storage pits and the practice of roasting grains to prevent them from sprouting when stored would all have improved the practice of agriculture. A further factor is that the crops themselves evolved to become more suitable for agriculture.

The plants evolved because humans selected the wild plants most useful to themselves for planting and this caused the preservation of certain mutations within those plants. The mutations involved concerned the size and taste of the edible parts of the plants, a high fruit to seed ratio within fruits and oily fruits or seeds. These selections were made more or less consciously by early farmers. However other selections which affected the plants methods of seed dispersal, germination and reproduction were made quite unconsciously.

When early farmers selected wild plants they choose plants with large edible parts. Plants with large edible parts, for example fruit and berries, produce seeds which when planted are likely to produce further plants with large edible parts. Crops such as peas, corn and many fruits are much larger than the wild plants they evolved from.

Human selection also affected the taste of seeds. Many wild seeds taste bad to prevent them being eaten by animals. However the occasional mutant plant will produce pleasant tasting seeds which can be planted and produce further pleasant tasting seeds. Almonds, lima beans, watermelons, cabbages and potatoes all had wild ancestors with an unpleasant taste or were poisonous. But when nice and safe mutants were cultivated by early farmers valuable crops were produced.

Fruits with much flesh and small or no seeds were also selected by early farmers. This led to such qualities becoming standard among domesticated plants. Oily fruits and seeds were selected by early farmers so cultivated plants such as olives became much oilier than their wild ancestors. Plants used for producing textiles like flax and hemp were selected for long stems as the fiber used to produce the textiles came from the plants stems.

Domesticated plants differ from wild plants in other ways. Many wild plants such as wheat and barley have mechanisms for seed dispersal which involves their stalks automatically shattering to spread the seeds on the ground. However there are mutant varieties of wheat and barley whose stalks do not shatter and these tend to be gathered by humans as it is easier to collect the mutants than the normal plants. When the mutants were planted they tend to produce more mutants so that non-shattering stalks became the norm for domesticated wheat and barley. A similar situation exists with wild peas that have exploding pods to disperse the seeds. Mutant peas in which the pods did not explode were most easily collected by early farmers and when the seeds were planted they produced crops in which the pods did not explode.

Annual plants in the wild often have germination inhibitors to stop the seeds all germinating at the same time making them vulnerable to a single frost or drought. When people first planted the seeds, mutants without germination inhibitors would sprout first and be harvested by humans so as to select the mutants without the germination inhibitors.

Most wild plants reproduce by fertilization from other plants. When this happens, mutations desirable for domesticated plants would be lost. Early farmer's selection of crops favored self-fertilizing mutants, as those plants retained the qualities desirable for farming, so that domesticated crops became self-fertilizing. This meant desirable attributes in domesticated species were not lost by fertilization from wild plants without those attributes.

There are roughly 200,000 wild plant species, but of these only a few thousand can be eaten by humans. Only a few hundred plant species have actually been domesticated and there are about a dozen plant species that make up over 80% of the crops people eat. These twelve species are the cereals wheat, barley, rice, corn and sorghum, the pulse soybean, the roots, manioc, potato and sweet potato and sugar cane and sugar beet and the banana.

The first crops to be domesticated were wheat, barley and peas in South West Asia about 10,000 years ago. The reason why these crops were the first to be domesticated was because the qualities of their wild ancestors made them the easiest crops to domesticate. The wild ancestors of these crops were edible and gave good yields and were easily planted or sown. They were quick growing and could be harvested a few months after planting and they were easily stored. Relatively minor genetic change was required before they were domesticated. They were usually self-fertilizing so desirable qualities were not lost by reproduction with other plants. The main genetic changes were the developing of non-shattering stalks and consistent rapid germination.

More difficult crops were domesticated somewhat later. Some fruit trees such as grapes, figs, dates and olives were domesticated about 4,000 BC. These crops do not provide food until more than three years after planting and may take as long as ten years to reach maximum production. Compared with other domesticated trees these crops are easy to plant as they can be grown from seeds or cuttings.

Trees such as pears, plums, cherries and apples were quite difficult to domesticate as they could only reliably be grown by grafting. Grafting was a difficult technique to develop as it could only be discovered by deliberate experimentation. The wild ancestors of these trees had the additional problem of not being self-pollinating so farmers had to plant other trees nearby or find self-pollinating mutants.

A number of plants became domesticated after first evolving as weeds in cultivated fields. These crops known as "secondary crops" only became domesticated in West Asia and Europe in the second and first millennia BC. Such crops included oats, turnips and probably lettuce, leeks and beets.

Strawberries and raspberries were not domesticated until medieval times. This was because wild strawberries and raspberries have very small berries that are of only limited value to people. It was not possible to select plants with larger berries to produce domesticated strawberries and raspberries with larger berries as birds which eat the small wild berries would defecate wild berry seeds everywhere and would interfere with human selection of plants with larger berries. Strawberries and raspberries were only domesticated when greenhouse or protective nets were used to protect selected plants from birds, allowing plants with extra-large berries, to be produced.

The first crops to be domesticated were those most easy to domesticate. The wild ancestors of wheat, barley and peas had the right qualities concerning taste, yields, ease of planting, rapid growth, ease of storage and minimal genetic changes needed for domestication, so they were the earliest plants to be domesticated. It was the qualities those particular crops had which made them easier to domesticate than other crops so they became the first crops to be domesticated. The next crops to be domesticated were fruit trees, which while they could be grown easily enough, did not provide food for some years after planting. Secondary crops which evolved from weeds in cultivated fields had to be domesticated after the earlier crops had been domesticated. Trees that could only be grown by using the difficult technique of grafting inevitably were domesticated after trees that could be grown from seeds or cuttings. Finally strawberries and raspberries were domesticated last due to undersize berries and the difficulty in selecting and growing plants with larger berries due to wild strawberries and raspberries inter-breeding with the selected plants.

The plants with the best qualities for domestication were domesticated first and those that were more difficult to domesticate or those that were less desirable, for example with a long period of growth required before food was produced, were domesticated later. The order of domestication was rational and was the order in which domestication was always going to take place.

A further important point concerning the domestication of plants is that plants, being living organisms, will evolve to fit in with the new environment the plants were put into. Larger edible parts, non-shattering stalks, consistent rapid germination and self-fertilization were attributes domestic plants developed in response to the new environment created for the plants by humans. This ability to evolve into more useful plants than their wild ancestors made the development and spread of agriculture much easier. There must be considerable doubt as to whether agriculture would have lasted if plants were not capable of evolving and humans could only grow the wild ancestors of domesticated plants. Certainly agriculture would never have become so widespread as it did if we could only grow wild plants. Again one sees a particular quality of plants, their ability to adapt to new environments, having a major effect on human history. If plants could not evolve there may have been little or no agriculture, sedentism may have been impossible apart from in a few environments that are endowed with an unusual abundance of food and human history would have been radically different.

Agriculture only became possible because, of the few thousand plants that people can eat, a few hundred of them were capable of domestication. The other edible plants could not be domesticated due to characteristics of the plants that made them unsuitable for domestication. Some plants are just so slow at growing they are uneconomic to grow. In other plants undesirable qualities, such as bitter tasting or small fruits or nuts, or shattering stalks and delayed germination, are controlled by a single gene and can be bred out of the plant by human selection. Where undesirable qualities are controlled by a number of genes it is far more difficult or even impossible to get rid of those qualities by selective breeding. The manner of seed dispersal used by certain plants can also make domestication difficult or impossible. Where seed dispersal is by animals such as squirrels it is very difficult for humans to select and isolate trees with desirable qualities. This is because the squirrels are constantly spreading seeds everywhere, including those with undesirable qualities, so it is not possible to prevent pollination of trees with good qualities by trees with undesirable qualities. The same problem existed for strawberries and raspberries whose seeds are spread by thrushes. Only when nets and glasshouses were used to isolate mutant strawberries and raspberries with desirable qualities were those plants able to be domesticated.

It is quite apparent that whether a particular plant can be domesticated depends on the particular characteristics of that plant. The length of time a plant takes to grow, its method of seed dispersal and whether it can evolve qualities humans desire for example if only a single gene controls the particular quality. All these qualities are ultimately controlled by the genetic make-up of the plant, so that whether a plant can be domesticated or not ultimately depends on the genetic make-up of the plant.

If the genetic make-up of all plants prohibited domestication, then agriculture would never have occurred. If agriculture had not been possible humans would have remained hunter-gatherers and sedentism would have been impossible except possibly for a few areas of very abundant food supplies. This almost certainly would have meant cities, civilization, writing and the industrial society many of us live in would never have existed. Obviously some plants, due to their genetic make-up, were suitable for domestication so agriculture was possible. But only about ten percent of the plants edible by humans were capable of domestication.

Different crops and different combinations of crops could have different effects on societies. Certain crops such as wheat require a system of field rotation due to nitrogen exhaustion in the soil. In Roman times a two field rotation system was used with half the land being left fallow each year to allow the nitrogen to be replenished by natural processes. By the 8th century AD crops such as a winter wheat, rye and legumes, such as peas and beans, began to be used in a three field rotation system. The three field system allowed two thirds of the land to be used each year with legumes being planted in one of the three fields as they restored nitrogen to the land. The increase in land use and the better nutrition provided by a wider range of crops allowed an increase in population in Europe that ended only with the famine and disease (the black death) of the fourteenth century.

Rice on the other hand is normally grown in paddy fields, where the water is muddy and the mud restores the fertility of the soil so that it is not necessary to leave any land to lie fallow. Rice is

often grown with sophisticated irrigation systems which require considerable organization to create and maintain. Wittfogel suggested that the need for building and maintaining the irrigation systems inevitably led to substantial state control and firm social discipline. It is also possible, from about the thirteenth century onwards, to grow two or sometimes three harvests of rice per year. Given that no land is left to lie fallow and that several harvests could be produced per year, rice growing areas such as Southern China, tended to have a high population density compared to Europe.

The principal crop that supported the Aztec and Inca civilizations in the New World, was maize. Maize grows quickly and produces extremely high yields and it is sometimes possible to have two harvests per year. It also requires little work to produce leaving people free to engage in other activities. In *Capitalism and Material Life 1400-1800* Fernand Braudel suggests:

“Maize on the irrigated terraces of the Andes or on the lakesides of the Mexican plateau brought about theocratic totalitarian systems and all the leisure at the disposal of the countryside was used for immense Egyptian style public works. Without maize the giant Mayan or Aztec pyramids, the cyclopean wall of Cuzco or the wonders of Manchu Pichu would have been impossible. They were achieved because maize virtually produces itself.” (Braudel Fernand (1967) *Capitalism and Material Life 1400-1800*, Fontana, London 111).

It seems likely that the type of crops, available to a particular society, will have a significant impact on the type of society that uses the crop. The type of crop available is determined by what nature provides us in terms of wild plants whose characteristics are determined by the genetic make-up of those wild plants. This means the genetic make-up of the wild plants on this planet has had a major effect on the type of human societies that have existed and on human history.

Humankind have domesticated fourteen species of large herbivorous and omnivorous mammals. The five most important of these are cattle, sheep, horses, goats and pigs. All of these animals are now distributed world-wide. Nine other large herbivorous mammals being two species of camel, reindeer, donkey, lama, water buffalo, bali cattle, mithan and yak have also been domesticated but are confined to particular areas. Ten of these fourteen animals became domesticated between 8,000 and 2,500 BCE, the remaining four animals having no clear date of domestication. Given that no large herbivores have been domesticated since 2,500 BCE even with modern scientific methods, it seems that all the animals that can be domesticated, have been domesticated.

In *Guns, Germs and Steel* Jared Diamond refers to there being 148 large wild herbivorous animals that could be considered for domestication. However, only fourteen of these were domesticated. (Diamond, Jared (1998) *Guns, Germs & Steel* London, 160-162). This is because in order for animals to be domesticated they must meet certain criteria. These criteria relate to the animals diet, breeding habits, rate of growth, social structure, inclination to panic and viciousness.

Domesticated animals must eat and if they consume an excessive quantity of food or have fussy eating habits they may be uneconomic to keep. Ideally they should consume low quantities of easily produced food such as grass or some other easily grown food. A domesticated animal will always eat far more food than it is able to produce for its human owners. It may take ten tons of food to produce one ton of herbivore. If the food is grass then that is not necessarily a problem but if the animal is a koala that only eats eucalyptus leaves or a panda who eats bamboo shoots it might not be worthwhile to keep the animal. The most important domestic animals eat easy to produce food, such as grass, and are not fussy about what they eat.

The reason no carnivore is domesticated as food for people is because the economics is even worse than for herbivores. If you want to produce a one ton carnivore you may have to feed it ten one ton herbivores. However the herbivores themselves would have to be feed with ten tons of feed each, so the total cost of feed for a one ton carnivore would be one hundred tons of food. This means domesticated animals were always going to be herbivores or omnivores.

An animal's breeding habits may also affect its suitability for domestication. Many animals will simply not breed in captivity, often because they require elaborate courtship rituals which are not possible in captivity. If an animal cannot breed in captivity, then it cannot be domesticated.

Some animals are not worth domesticating due to the length of time it takes them to reach maturity. If you have to feed your animal for ten or fifteen years before it is fully grown it may not be worth domesticating the animal.

The vast majority of domesticated animals have wild ancestors with three particular social behavior traits. These are that the wild ancestors have a dominance hierarchy, they live in herds and the herds do not occupy exclusive territories. Animals with a dominance hierarchy are easier to domesticate as they treat their human owner as the dominant animal and are easily able to be lead around by the human. Animals used to living in herds are easier to domesticate as they are comfortable with being penned in small spaces with many other animals. Animals that do not occupy exclusive territories are easier to domesticate as they can be easily mixed in with animals from other herds without fighting.

Some animals have an inclination to panic when they feel threatened. If put in fenced enclosures they might charge the fence in an attempt to escape and either injure or kill themselves. Alternatively they might die of shock if kept penned up in an enclosed area.

The final problem with domesticating animals is that many are so vicious that it is dangerous for humans to be around them. Animals like large bears, the African buffalo and zebras cannot be domesticated as they are just too dangerous to have living among humans.

Unless large herbivores meet all of the criteria of eating the right foods, being able to be breed in captivity, having a good rate of growth, the right social habits, are comfortable with being enclosed and are not too dangerous to people then they cannot be domesticated. If any of these factors are not present, then the animal cannot be domesticated. This is why only fourteen out of the one hundred and forty eight large herbivores have been domesticated.

The qualities animals need in order to be domesticated are dependent upon the genetic make-up of those animals. If those fourteen large domesticated animals did not have the right genetic make-up then they would not have been able to be domesticated. If there were no large domestic animals all those societies we describe as pastoralist would not have existed. There would have been no Mongol Empire, no Mongol conquests of China and most of Asia. The Roman Empire may not have fallen, it certainly would not have been invaded by Goths and Huns mounted on horses. Many of the infectious diseases that cause illness and death in humans appear to have originated from domestic animals. Smallpox, tuberculosis and measles appear to have come from cattle, while the flu has come from pigs and ducks. If these animals had not been domesticated humans may well have never caught those diseases. If there had been no large domesticated animals there would have been little or no plough agriculture as there would have been no horses or oxen to pull the plough. With no horses, oxen or other large domestic animals to pull carts or wagons or to serve as pack animals the transport of goods and people over land would have been much more difficult. Everything would have had to be carried by people.

A good idea of what societies without large domestic animals would be like can be seen by looking at the Aztec and Inca civilizations in the New World. The Aztecs had no large domestic animals at all and the Incas only had the lama which is nowhere near as large or as strong or as cooperative as horses or oxen. The Aztecs had the idea of the wheel which they used on children's toys but they had no carts or wagons due to having no animals to pull them. Both the Aztecs and the Incas practiced hoe agriculture, breaking the ground with a digging stick before planting the seeds. With no large animals to pull ploughs, plough agriculture was not practicable. If large domestic animals had existed in the New World, they almost certainly would have been used as can be seen from the way in which Native Americans, on the plains of North America, used the horse when it became available. One of the major factors in the Spanish conquest of the Aztec and Inca empires was the lack of large domesticated animals in the New World. The Spanish had cavalry, while the Aztecs and Incas had none and the Spanish came with smallpox to which the people of the New World had no immunity. The disease ran through the Aztec and Inca populations killing millions and greatly assisting the Spanish conquest of those empires. Clearly the presence or absence of large domesticatable animals can have a great effect on a society. The presence or absence of such animals is determined by the genetic make-up of the large, wild herbivorous animals nature has evolved. This means the genetic make-up of such animals can determine the types of human societies that have existed and human history.