



Building blocks of agriculture



Authors:

Juri van den Heever¹ 

Chris Jones² 

Affiliations:

¹Department of Botany and Zoology, Faculty of Science, Stellenbosch University, Stellenbosch, South Africa

²Department of Systematic Theology and Ecclesiology, Faculty of Theology, Stellenbosch University, Stellenbosch, South Africa

Corresponding author:

Chris Jones,
chrisjones@sun.ac.za

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The origins of agriculture lie in the distant past, approximately 12000 years ago, when hunter-gatherers of the Palaeolithic embraced sedentism at the dawn of the Neolithic. The variety of life history transitions emanating from this unique phenomenon have had an enormous impact on the biodiversity of the planet, while subjecting humanity to a variety of life-changing physical and social challenges right up to the present. The ever-present consequences of the Agricultural Revolution continue to demand our attention, yet frustrate our efforts, on a seemingly perpetual basis, to effectively manage the outcomes. Here we review the origins and lasting after-effects of the Agricultural Revolution and its impact on the human condition, with reference to sedentism, nutrition, health issues, disease, gender discrimination as well as mythmaking and religion.

Contribution: Our aim is to engage a wider audience with respect to the causes and consequences of the Agricultural Revolution. We discuss a broad spectrum of relevant phenomena implicated in this epochal event and consequently underline that the Agricultural Revolution precipitated not only major changes to the ecology of the planet, but also and most importantly to the social and cultural well-being of humanity.

Keywords: Agricultural Revolution; gender discrimination; horticulture; husbandry; life history transitions; Neolithic; Palaeolithic; health, religion; sedentism.

Introduction

Historically, human populations have, over millennia, repeatedly adapted to changing environments and social conditions, an activity known as niche construction. The prime example of such subsistence niches is perhaps the Agricultural Revolution, commencing around 12000 years ago, as the Palaeolithic (Old Stone Age) gave way to the Neolithic (New Stone Age). Many researchers have stressed the importance of this life-changing phenomenon in the recent history of humankind. Atkins, Simmons and Roberts (1998:13) are of the opinion that '[n]o other single change in human history can have had a greater effect upon the landscape than the domestication and global spread of plants and animals'. From a more cultural assessment of this phenomenon, Hershkovitz and Gopher (2008:442) proclaim that '[t]he transition from hunting and gathering to farming – the Neolithic Revolution – was one of the most significant cultural processes in human history that forever changed the face of humanity'.

Christian (2019:188) also notes that human existence was vastly transformed when hunting and gathering morphed into sedentism. He eloquently concurs that it initiated the founding of villages and a cascade of innovative changes:

Farming was a mega-innovation, a bit like photosynthesis or multicellularity. It set human history off on new and more dynamic pathways by helping our ancestors tap into larger flows of resources and energy that allowed them to do more things and create new forms of wealth. (p. 188)

The Agricultural Revolution is thus firmly established and universally recognised as an epoch-making turning point in the life history, not only of *Homo sapiens*, but of the entire biodiversity of the planet as well. 'There have been few developments that have been more important for the human race than the agrarian Neolithic Revolution' (Armstrong 2018:43). The Agricultural Revolution eventually crystallised into full sedentism, animal husbandry and horticulture, which translates as permanent villages and cities, cultigens and domesticated livestock.

The metamorphosis from a hunter-gatherer existence to an agrarian lifestyle was by no means a smooth transition, as different populations around the world experienced the ups and downs of mastering sedentism at a different pace, in different climates and at different times. Wells and

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Stock (2020:1) point out that by 20000 years ago, in the run-up to the Neolithic, human populations of the Late Palaeolithic were already investing in long-term settlements and resourcing wild grain in the Levant. Arranz-Otaegui et al. (2018:1) have presented archaeobotanical evidence showing that by 14400 years ago, Natufian hunter-gatherers from Shubayqa 1, a site in north-eastern Jordan, were preparing and consuming bread-like products.

Some of the most compelling evidence of the transition to agriculture surfaced at the site of Tell Abu Hureyra, a small village located along the Euphrates River in the north of modern Syria. Christian (2019:198) mentions that the earliest levels of occupation date to about 13000 years ago. The inhabitants then subsisted on hunting and a selection of plant foods which included fruit and wild grain. A 1000-year cold period forced the inhabitants to increasingly rely on the more climate-resistant grain, eventually abandoning the site. Around 11000 years ago, the site was reoccupied as a large, thriving, agricultural settlement, farming domesticated grain and sheep, as is evinced by the sudden increase in sheep bones and the large grinding stones uncovered at the site. In the case of Abu Hureyra, at least, it appears that the transition to agriculture can be ascribed to climate change.

The upshot thus was that as agrarian societies systematically developed over a period of time, people were increasingly living and working in close proximity to a greater number of people, as well as a variety of domesticated animals and plants. According to Watkins (2015:153), hunter-gatherer communities progressively embraced the new lifestyle between c. 22000 and 12000 years ago. In addition to hunting and harvesting wild plants, they gradually settled in larger groups than before, creating semipermanent settlements that eventually, at the dawn of the Neolithic, evolved into permanent settlements five to ten times larger than before. 'From at least the beginning of the Neolithic, some of these communities were cultivating crops of wheat, barley, lentils and other pulses' (Watkins 2015:153). He also notes that some researchers regard the pressures generated by population density, as a result of sedentism, actively led to the development of farming and herding, sparking the need for ways of effectively storing harvested produce. More recent suggestions also favour climate change as a viable explanation for the rise of agriculture, suggesting that the drier and cooler climate at the beginning of the Neolithic indicates a decline in wild food resources.

In contrast, Watkins (2015:154) attributes the transfer to the new way of life of sedentism and agriculture to the cognitive initiative of hunter-gatherers between 22000 and 12000 years ago. Because hominins have evolved a brain so large that it exceeds the physical requirements of the body, '[h]ominin brains and minds deploy cognitive and social skills that enable them to live in larger and more cohesive and cooperative social groups' (Watkins 2015:154).

Bowles and Choi (2019:2186–2188) dispute the standard explanations regarding the founding of agrarian societies.

They believe that to invest in an agricultural existence would be futile without what they term as '... possession-based private property ...' (Bowles & Choi 2019:2186). For them, this translates to having dominium over cultivated plots, dwellings and private storage facilities. Accordingly, they propose that '[s]ome elements of private property were almost certainly common even amongst mobile hunter-gatherers' (Bowles & Choi 2019:2188). Their model of the Agrarian Revolution consequently underscores an economic model based on private ownership. In their view, '[o]nce independently established, the Neolithic economic model (farming plus private property plus sedentism) out-reproduced foraging populations' (Bowles & Choi 2019:2221). It therefore appears that the underlying reasons for the Neolithic Revolution may have been more complex and varied than previously recognised and cannot be comprehensively accounted for by a simplistic approach.

However, much greater consensus exists with respect to the way communities adapted their subsistence niches in terms of lifestyle and the acquisition of food with the advent of changes wrought by the Agrarian Revolution:

The shift to farming is widely understood to have impacted several aspects of human demography and biology, including mortality risk, population growth, adult body size, and physical markers of health. (Wells & Stock 2020:1)

In conjunction with the physical and health consequences that co-evolved with the emergence of agriculture, we have identified additional areas of human culture that have also undergone significant modification. Amongst these are what may be the first attempts at a legal system of sorts, circumscribing access to and use of land for pasture and cultivation (Bowles & Choi 2019:2221), the well-documented, incipient stages of gender discrimination and important adjustments to mythmaking and religious practices. These cultural innovations have also had important and life-changing outcomes throughout the subsequent millennia, shaping human attitudes, moral parameters and religious convictions right up to the present day, and thus they form part and parcel of the physical and cultural outcomes of the Palaeolithic–Neolithic transition under the overarching umbrella of agriculture and sedentism.

Because these wide-ranging aspects are often discussed in isolation, we have followed a more inclusive approach regarding the causes and consequences of the Agrarian Revolution and have presented the factual background of this unique transition under selected headings, in an attempt to provide a more comprehensive springboard for further research.

Discussion

Origins of agriculture

As Palaeolithic communities increased their skills at accumulating, interpreting and managing knowledge about their lifeworld, they became increasingly proficient hunters

and gatherers. In turn, their mastery of the environment increased in parallel. In some parts of the world fire-stick farming, also known as cool burning or cultural burning, as well as slash-and-burn agriculture have been practised, in a sustainable way, for thousands of years. Kershaw et al. (2011) comment on fire-stick burning and note that, long before the Neolithic:

The earliest dates around 40000 years BP (46000 calibrated years BP) for the most likely time of initial human impact on Australian vegetation are consistent with the most recent archaeological evidence for the presence of people, considered to fall between 50000 and 42000 years BP ... (p. 21)

According to Pedroso-Junior, Adams and Murrieta (2009:15) slash-and-burn agriculture dates back to the boundary between the Palaeolithic and the Neolithic '... when human populations gradually switched from hunter-gathering to the more sedentary habits of agropastoral activities'. They are also of the opinion that even before agricultural practices became established, humans employed fires as a tool which indirectly influenced forest ecosystems and climate (Pedroso-Junior et al. 2009:15). The benefits of fire-stick and slash-and-burn activities are that they temporarily provide fertiliser, increase production of plants and animals useful to humans and eradicate weeds and other undesirable growths:

When Captain Cook and his crew sailed north along the east coast of Australia in 1770, they did not see wilderness. They saw distant spirals of smoke as Australians fired the land, and they saw landscapes as altered by human activity as the country gardens of their English homeland. (Christian 2019:210)

In retrospect, it turns out that the Aborigines have employed fire-stick agriculture for many thousands of years and consequently effected a hugely positive impact on the ecology of Australia (see Gammage 2012 for an in-depth analysis of this phenomenon).

It stands to reason that the Agricultural Revolution did not surface simultaneously across the world. Lack of communication, different environmental conditions, human ingenuity and serendipity probably all played a role and resulted in different timelines for different domesticated crops and animals. During the 19th century, under the influence of the Christian tradition, it was assumed that agriculture originated in the lands of the Bible, otherwise known as the Fertile Crescent. Subsequent research has identified four areas, viz. Northern China, the Middle East, Southern Mexico and Central and South Peru, as early points of origin, suggesting that the initial attempts at agriculture were widespread and that it evolved independently in different regions across the world. Thus, agriculture remains as the earliest known example of the reciprocal influence between the environment and fully modern humans on a scale that produced such momentous and lasting outcomes. Ultimately, it led to the domestication of about 1900 species. However, the Middle East remains an important node. '... in the domestication of the cereal species, especially wheat and barley, and animals such as sheep and cattle, all of which later were to become key

staple items in the diets of western, developed nations' (Atkins et al. 1998:14).

Archaeobotanical data from China indicate at least three independent centres of origin of agriculture. Dry-land agriculture of foxtail, located along the Yellow River between the southern border of the Mongolian steppe to the north and the Huai River to the south; the wetlands along the middle and lower Yangtze River utilised to produce rice; and an area along the Zhujiang River, south of the Nanling mountains, where ancient tropical agriculture predominantly produced crops that reproduced vegetatively (Zhao 2011:304). Foxtail refers to various grasses where the foxtail, or spikelet, at the tip of the stem dislodges easily and aids seed dispersal. Neolithic farmers bred for retention of the grains on the stem to aid harvesting. By 10000 years ago, Chinese hunter-gathers were regularly making use of wild broomcorn millet, and by 8000 years ago it was first domesticated.

According to Zhao (2011:304), rice cultivation was initiated c. 10000 BP in areas along the Yangtze River. Doubt exists as to whether it was already a domesticated species in terms of morphology and genetics or, more likely, an early attempt to increase the yield of wild rice. From 9000 to 6500 BP is regarded as a transitional period between hunting and gathering and settling down to farm rice. It stands to reason that the transitional phase developed gradually from the hunting and gathering lifestyle, supplemented initially by incipient rice farming and attempts at animal domestication. Zhao (2011) reveals that rice farming gradually increased in importance in China from 6500 to 4500 BP to the extent that rice became the staple food:

Full rice agriculture was first established in the middle Yangtze River region about 6400–5300 BP, a period known as the Daxi culture, and then in the lower Yangtze River region about 5200–4300 BP, during the Liangzhu culture period. (p. 304)

A holistic approach is therefore necessary for any in-depth assessment of the origin, progression and consequences of the Neolithic Revolution.

Christian (2019), stressing the importance of agriculture and sedentism, notes that farming villages and their populations provided most of the human and material resources that have sustained the civilisations that dominated the past 5000 years of human history:

Look behind the imperial armies and cities, the temples and pyramids, the trade caravans and shipping fleets, the literature and art, the philosophies, and religions of agrarian civilizations, and you will find, in the background, often far from the heartlands, thousands of farming communities, as well as a large and even poorer population of vagrants and the dispossessed, many of whom were slaves. People from these underclasses produced most of the grains and meat, many of the linens and silks, and much of the labor (both free and unfree) needed by the great cities. (p. 211)

In this way, agrarian civilisations were built on foundations created by the evolution of farming communities over several millennia.

Domestication

One of the beneficial outcomes of the Agricultural Revolution has been the changes wrought in the lifeworld of a select group of plants and animals. This process, known as domestication, entails the breeding of successive generations of plants and animals in order to promote traits preferred by humans, such as increased production of fruit, seeds, milk or meat. Plants altered in this way are called cultigens and are known for their ease of harvesting and resistance to disease. However, as the result of human interference in the existence of these plants and animals, they have, over time, also become increasingly dependent on humans for propagation and survival. In addition, the cumulative after-effects of this type of ecological engineering have had a hugely negative effect on incalculable life forms, while enabling humans to increase disproportionately in numbers (aided in parallel by spectacular advances in the health and nutritional sciences).

Plants

Cultigens have been developed at various times from a wide range of species. Grasses, beans and potatoes are especially well represented because they possess characteristics that are particularly amenable to domestication. Some of the first crops domesticated by Neolithic farmers in the Fertile Crescent included cereal species like emmer wheat, einkorn and barley.

In Mexico, squash was already under cultivation about 10 000 years BP, while in southwestern Mexico domesticated, maize-like crops appeared around 9000 years ago. It was probably developed from teosinte (*Euchlaena mexicana*), a wild grass, and improved over time to the level of a staple diet. A crucial process, known as nixtamalisation, is an integral part of maize production and it entails boiling the dried kernels in a mixture of water and ash to remove the outer cover. Nixtamalisation makes maize more digestible, greatly increases the available calcium, makes proteins more accessible and enhances flavour. A population that depends on untreated maize as a staple food risks malnourishment and is more likely to develop deficiency diseases such as pellagra, niacin deficiency or kwashiorkor (malnutrition as the result of a lack of certain amino acids, particularly affecting young children in the tropics). Eventually, the cultivation of maize spread to other regions of the world, unfortunately unaccompanied by the recipe for nixtamalisation. Consequently, in 19th century France, Italy, the Deep South in the United States of America and parts of modern Egypt, South Africa and India, pellagra outbreaks became common.

Animals

Domesticated animals tend to have been developed from species that are social in the wild and, like plants, could be bred to enhance the traits desired by humans. Most domesticated animals are more docile and productive than their wild counterparts, and supply more meat, milk, wool and hides. Goats, sheep and pigs feature as some of the earliest domesticated mammalian species of the Agrarian Revolution, while widespread use of beasts of burden like

the horse and cattle followed thousands of years later. However, Scheu et al. (2015:9) have shown that the original domestication of cattle was a small, localised event in Southwest Asia, as early as the ninth millennium BC, and only spread to Western and Northern Europe thousands of years later. As humans eventually developed trade routes, donkeys and other pack animals came into use around 6000 years ago, and with camels sometime during the first millennium BC. The first livestock were, in all likelihood, the offspring of prey animals hunted for their meat. It is conceivable that domestication and husbandry were initiated by raising the infants of mothers that fell victim to hunters, or as in the case of wolf pups, which were already genetically adapted to life in a hierarchically structured social system, they more easily transferred their loyalty to the equivalent human version.

Health and agriculture

In order to gain some appreciation of the differences between the lifeworld of the hunter-gatherers of the Palaeolithic and the agrarian communities of the Neolithic, the lifestyle characteristics of extant hunter-gatherer societies provide the most useful insights. In short, it appears that the Palaeolithic communities were much more disease-free, following a more varied and healthy diet consisting of less meat and fat but rounded out with substantial amounts of seasonal plant material, including fruit and nuts. As a result, malnutrition was less prevalent. They experienced less hunting and social violence and consequently led less stressful lives. It is understandable then that they are often referred to as the first affluent communities.

The consequences of sedentism and the perpetual proximity of domesticated animals in settlements precipitated various health issues in the Neolithic, and as a result, in some cases, the health profiles of Neolithic agrarian populations differ markedly, with regard to their forerunners:

Various studies revealed an association between the advancement of agriculture and change in the health status of human populations. The most common changes reported are pathological conditions which were induced by a combination of factors, including a higher rate of infection, a decline in the overall quality of nutrition, and an increase in physical stress. (Eshed et al. 2010:122)

Selected pathogens flourish as the result of high population densities and close human–animal contact, and these conditions enabled vector-borne infectious diseases like smallpox, influenza and measles, which are still with us, to jump species during the Agricultural Revolution.

Eshed et al. (2010:122) assessed the differences in health profiles between the pre-Neolithic (Natufian) and Neolithic populations in the southern Levant. This region is acknowledged as one of the prime candidates for the origin of agriculture, although it is evident that agriculture had multiple areas of origin around the world, each with specific characteristics. They unveiled a substantial increase in

inflammatory diseases and a decrease in skull trauma, especially in Neolithic males:

These observations suggest that in the Levant the advent of agriculture did not simply lead to an overall deterioration of health but rather resulted in an altogether different health profile which is sex-specific and may have also varied by region. (Eshed et al. 2010:130)

Taking into account the difference between male and female activities in a subsistence economy, they found that male life expectancy at birth increased while female life expectancy declined. 'It involved an increase in fertility and a subsequent increase in mortality risk during pregnancy and especially during birth for Neolithic women' (Eshed et al. 2010:130).

Traditionally, the initial domestication of animals and plants has received much attention from researchers, as did changes in social and cultural patterns. Hershkovitz et al. (2021) have shown how changes in lifestyle and diet at the beginning of the Neolithic have affected the gross morphology of the lower jaw and long bones. They argue that our species has successfully adapted to the environment, both anatomically and physiologically, over the course of hundreds of thousands of years to emerge as efficient hunter-gatherers who experienced, until c. 15 000 years ago, a basically stable lifestyle (Hershkovitz et al. 2021:71).

The Neolithic shift to an agricultural lifestyle introduced changes to daily life in terms of physical activity, diet, health and demography. 'However, the population's biological adaptation could not occur at the same pace, leaving Holocene people seemingly trapped in the body of Upper Paleolithic hunter-gatherers' (Hershkovitz et al. 2021:72). Hershkovitz et al. (2021:77–79) note that during the Holocene, human populations were subjected to substantial changes in terms of behaviour and culture over a relatively short time:

Our study of the skeleton and mandible of Levantine Holocene populations clearly shows a reduction in their size and general robusticity, over time. With the changes in lifestyle, diet, and food preparation techniques, there was probably no longer a need to maintain a massive masticatory and locomotory system, which requires significant energy. (p. 79)

On a different level, David Fielding (2014:863) has pointed out that human social evolution has been greatly influenced by the invention of the hand plough, which, amongst other things, has created gender norms that still persist. One of the negative spin-offs has been that its operation required men with greater upper-body strength, which correlates with elevated levels of androgens and the incidence of many cancers:

Analysis of international data reveal evidence that the ratio of male cancer risk to female cancer risk is higher in populations descended from societies that adopted the plow during the Neolithic agricultural revolution. (Fielding 2014:876)

Evidence suggests that biological evolution is responsible for the differences in cancer risk. As this phenomenon cannot be

the consequence of differences in sexual behaviour, it is therefore an evolved trait:

One plausible evolutionary mechanism is that plow agriculture created an economic environment that favored the selection of men with greater upper-body strength, higher testosterone levels, and therefore a higher incidence of certain types of cancer. (Fielding 2014:876)

According to Wells and Stock (2020:1), all these trends have not previously been integrated in an encompassing and overarching framework and consequently cannot clearly elucidate the reasons why population increases took place in times of decreasing overall health. According to Armelagos, Goodman and Jacobs (1991:9), population growth after the development of agriculture has been one of the most dramatic features of human evolution. It is estimated that 10 000 years ago the human population tallied approximately 8 000 000 and by AD 1800 reached the 1 000 000 000 mark.

Traditionally, this phenomenon was ascribed to a general increase in health, as the result of a readily available and nutritious diet. This assumption proved inaccurate as sedentism and an increasing focus on agriculture actually increased the prevalence of infectious diseases and nutritional deficiencies, increasing mortality by specifically targeting children, infants and the elderly:

However, the Neolithic mortality pattern (the very young and the very old) is not as socially or reproductively disruptive as the pattern of zoonotic diseases among hunter-gatherers (which primarily affects the producers). (Armelagos et al. 1991:20)

The primary producers in Neolithic populations had attained some immunity against zoonotic diseases and could offset increasing mortality by shortening birthing intervals, thus precipitating a pronounced surge in population numbers.

Human reproduction is a complicated process and is influenced by a wide variety of physiological, genetic and physical conditions. Helle, Lummaa and Jokela (2002) have remarked on the critical balances involved in human reproduction and have shown that a larger number of male births reduces the expected longevity of the mother, but with daughters, it is just the opposite:

In humans, sons are physiologically more demanding to produce than daughters, as is indicated by their faster intrauterine growth rate ... and heavier birth weight ... and the longer time it takes mothers producing sons to reproduce again. Large, and particularly strongly male-biased, family size is thus predicted to reduce maternal longevity. (p. 1085)

Utilising data from Finnish church records, Helle et al. (2002) showed how family size and the number of sons and daughters related to the longevity of pre-industrial Sami women in northern Scandinavia. Their results indicate that maternal longevity was not related to the total number of children that attained adulthood, but they found a distinct gender bias in costs of reproduction on maternal longevity. In direct terms, giving birth to sons significantly shortened the

expected lifespan of the mother. Giving birth to daughters had a positive but statistically insignificant effect on maternal longevity. However, taking into regard the numbers of sons and daughters raised to adulthood, the positive effect on maternal longevity outstripped the negative effect of producing sons. Helle et al. (2002) suggest that this gender bias is the direct result of the lower maternal physiological costs incurred by producing daughters as opposed to sons, and the fact that daughters act as helpmeets daily reduces the physicality of the maternal workload. Additionally, male foetuses subject the mother to increased maternal testosterone levels. 'Testosterone is an immunosuppressor and may thus play a role in accelerating immunosenescence and consequently decreasing the survival into old age of mothers who have born several sons' (Helle et al. 2002:1085). Their results indicate that both reproductive investment and gender-based family structure appear to be important indicators of female life span and would in all probability also have been a factor in Neolithic agrarian sedentism.

Gender and agriculture

The prominence of gender issues in modern society, for example, international sporting events, often disregards their historical origin. Gender discrimination appears to be rooted in the Agricultural Revolution of the Neolithic. In modern, mobile hunter-gatherer societies, there is a distinct lack of gender discrimination as decision-making and influence within such groups are most often equally divided between men and women:

While modern-day hunter-gatherer societies are not the same as those living thousands of years ago, both historically and in modern times, the evidence is they tend to be relatively egalitarian. The highly mobile groups that save no food or other resources are particularly equal. In these groups no person has authority over any other; this lack of authority also means a lack of dependency. (Lewis & Maslin 2018:361)

Farming practices and innovations that may be regarded as mixed blessings included the invention of the plough:

This comparative advantage was not a feature of the horticultural systems that preceded the invention of the plow, in which land was prepared by hoeing, and weeding. Communities adopting the plow, evolved social norms to facilitate an economically efficient sexual division of labor, with men working in the field and women working at home. (Fielding 2014:864)

Fielding (2014) points out how the invention of the plough played a key role in human social evolution. The physical strength required to efficiently control a plough gave men a comparative advantage in an economically productive activity; this created gender norms that have persisted to the present day. However, there is an additional channel through which the invention of the plough could have influenced modern human societies: the creation of an economic environment favouring not only sexual division of labour but also the selection of men with more upper body strength. This division of labour remains real in modern-day subsistence agricultural communities to the extent that in

many traditional societies, women are not allowed to touch a plough. This has evolved into the situation where the use of the plough in subsistence economies has exacerbated gender differences between men and women. In societies where the plough is absent, most of the agricultural tasks still fall to women.

Alesina et al. (2013) studied gender roles with reference to agricultural practices in the pre-industrial era. Their findings also indicate that when the hoe and the digging stick, traditionally wielded by women, were replaced by the plough, women were marginalised:

Unlike the hoe or digging stick, the plow requires significant upper body strength, grip strength, and bursts of power, which are needed to either pull the plow or control the animal that pulls it. Because of these requirements, when plough agriculture is practiced, men have an advantage in farming relative to women. (p. 470)

At the time, these practical considerations underscored the perception that the physical abilities of women were best confined to the home environment:

These cultural beliefs tend to persist even if the economy moves out of agriculture, affecting the participation of women in activities performed outside the home, such as market employment, entrepreneurship, or participation in politics. (Alesina et al. 2013:471)

More surprisingly, they also note that:

Our findings provide evidence that current differences in gender attitude and female behaviour are indeed shaped by differences in traditional agricultural practices. Specifically, we have shown that individuals, ethnicities, and countries whose ancestors engaged in plough agriculture have beliefs that exhibit greater gender inequality today and have less female participation in non-domestic activities, such as market employment, firm ownership, and politics. In an effort to better identify a channel of cultural persistence, we examined the children of immigrants. We find that among these individuals who face the same labor markets, institutions, and politics, a heritage of traditional plough agriculture is still associated with more unequal gender attitudes and less female labor force participation. (Alesina et al. 2013:527–528)

Gender discrimination is one of the by-products of the Neolithic Revolution that has endured for millennia, in various walks of life, right up to the present. Traditionally, seemingly against all reason, some of the most vociferous and outspoken supporters of gender discrimination have been religious denominations around the world.

Religion and agriculture

The Neolithic world was not uniform but varied and dynamic. One cannot speak of a Neolithic religion but rather of Neolithic religions. Taking into consideration the major changes that the Agricultural Revolution wrought in the life and times of Neolithic humans, it seems evident that the spirit world would also have been subject to new and innovative adjustment. Atkins et al. (1998:14) are of

the opinion that '[t]he domestication of plant [*sic*] and animals are both intricately linked with religion and ritual and underlie many myths, a somewhat derogatory word applied to other peoples' religions'. According to Watkins (2015:157), '[s]hared religious ideas about supernatural agency and systems of religious belief and practices can be argued to be a very recent cognitive ability of *Homo sapiens* ...'. Religious observance, centred around a belief in a spirit world, and perhaps the reward of an afterlife, appears to be a universal concept amongst humans. Dunbar (2005:185) has shown that religion is a social activity that requires at least fourth-order intentionality. 'That being so, then it is perhaps obvious why humans – and only humans – seem to have religious systems. Only humans can aspire to fourth-order intentionality as a matter of course' (Dunbar 2005:186).

The archaeological site of Çatalhöyük in southern Turkey is one of the best-preserved Neolithic settlements and has provided an increased understanding of the transition from a nomadic life of hunting and gathering to an agricultural lifestyle. The mud-brick dwellings at Çatalhöyük are c. 9500 years old and may have housed 8000 people. The inhabitants are thought to have valued spirituality and art as the deceased were interred under the floors of houses, and hunters, goddesses and cattle were pictured on the walls. Entombing the bodies of relatives in living areas was an obvious way to have them near and may have served to facilitate daily contact with the ancestors. Hodder (2011) is of the opinion that at Çatalhöyük:

Religion played a primary role, allowing new forms of agency, setting up a symbolic world of violence through which new longer-term social and economic relations could be produced, but there is not good evidence that it was an independent cause of changes. (p. 121)

Armstrong (2018) is convinced the Neolithic discovery that the earth was an apparently inexhaustible font of nourishment was the basis of what she terms the Mythology of the Farmers. 'The people of the Paleolithic regarded hunting as a sacred act and now farming also became sacramental' (Armstrong 2018:44). Because farming was linked to the sacred, its practice required a state of ritual purity and, as the magic of subterranean germination and growth remained unobserved, just as in a living womb, the soil was interpreted as under the control and guidance of a divine hand. As a result, rituals were created to sustain these beliefs. One form of offering was to dispose of the first seeds and leave the first fruits unpicked. The implicit principle being that in order to receive, a counteroffer had to be put on the table. The sacred was thus not ephemeral and distant, like a Sky God, but embedded in the soil and seasonally unveiled by the sacred harvest:

In early Neolithic mythology, the harvest was seen as the fruit of a hierogamy, a sacred marriage: the soil was female; the seeds divine semen; and rain the sexual congress of heaven and earth. It was common for men and women to engage in ritual sex when they planted their crops. Their own intercourse, itself a sacred act, would activate the creative energies of the

soil, just as the farmer's spade or plow was a sacred phallus that opened the womb of the earth and made it big with seed. (Armstrong 2018:45)

These myths were extremely powerful and resilient, enduring for thousands of years as important principles guiding farming practice and ultimately surfacing in religious texts:

The bible shows that these ritualised orgies were practised in ancient Israel, well into the sixth century BCE, to the fury of such prophets as Hosea and Ezekiel. Even in the Jerusalem temple there were ceremonies in honour of Asherah, the fertility goddess of Canaan, and a house of sacred prostitutes. (Armstrong 2018:45–46)

At the time, human procreation was invested with danger, and farming required intense and hard labour. Armstrong (2018) draws the comparison that:

In the book of Genesis, the loss of the primordial paradisaic state is experienced as a falling into agriculture. In Eden, the first human beings have tended God's garden effortlessly. After the Fall, the woman brings forth her children in sorrow, and the man has to wrest a living from the soil by the sweat of his brow. (p. 49)

Life history transitions and agriculture

Wells and Stock (2020:1) mention the generally accepted view that the origins of agriculture precipitated changes in human demography and biology, commonly reflected in aspects such as mortality risk, population growth, adult body size and physical markers of health. They point out that owing to the multiple transitions at the dawn of agriculture, there has been no previous attempt to holistically integrate all these changes. Consequently, they have proposed an innovative model, utilising the life history transitions at the origin of agriculture to assess the various demographic and biological markers in an effort to explain the impact of niche construction on humans. They point out that life history theory enables biologists to study general phenotypic variability in populations over time, as well as addressing '... phenotypic variability or change that arises both through genetics, adaptation, and also through mechanisms of plasticity, whether physiological, developmental, or behavioural' (Wells & Stock 2020:3). It provides a valuable tool but operates under certain constraints and assumptions:

Life history theory considers how organisms maximise their genetic fitness through harvesting resources from the environment, and investing them in a suite of biological functions throughout the life-course ... in practice the theory gives priority to energy and time as the most important resources and assumes that organisms making the best use of energy over their lifespan will receive the highest fitness payoffs. The theory assumes that for any individual organism, the supply of energy is finite, and that allocating more energy to one function precludes its allocation to other functions. (Wells & Stock 2020:3)

They have also adjusted the traditional view of the competing life history functions of maintenance, growth and reproduction to include a fourth function, termed defence:

Maintenance refers to keeping the body in good condition through diverse homeostatic processes, thereby promoting longevity and

maximising the future opportunities for reproduction. Growth refers to the process of development and maturation and typically occurs prior to reproduction in most mammals. Reproduction refers to all processes involved in finding a mate, producing offspring and investing in them, and essentially allocates energy to the next generation. (Wells & Stock 2020:3)

Defence is additionally defined as a separate function against pathogens and predators. For them, life history trade-offs are primarily influenced by the ecological factors such as the supply of resources (energy) and the risk of death:

First, organisms subject to high mortality risk are unlikely to maximise fitness if they prolong the period of growth, instead selection favours earlier reproduction ... Second, all other things being equal, a greater supply of energy allows individual organisms to grow bigger, or the number of offspring produced to be greater, or the investment per offspring to be increased, promoting offspring fitness ... For example, adult stature is a marker of investment in overall growth, adipose tissue is a marker of investment in reproduction for females, and in defense (for funding immune function) for both sexes, while organ mass and quality are markers of investment in maintenance. (Wells & Stock 2020:3-4)

Exploring the six possible permutations between these functions, they evaluate alternative trade-offs against the amount of energy available to organisms and offer a resolution to the apparent paradox of surging population growth in the face of a decline in health. Wells and Stock (2020) conclude that:

The primary change appears to have been a systematic shift toward allocating energy to reproduction and defence, indicated by population growth and both direct and indirect indications of higher infectious disease load. This shift reduced the energy available for growth and maintenance, indicated by declines in stature and an increase in markers of degenerative bone disease. (p. 22)

Mummert et al. (2011:298) have suggested that declining health in a population could have been offset by shortening the interval between births, thereby boosting population numbers, albeit at a cost to women of reproductive age, children and infants.

Conclusion

There exists a general consensus amongst researchers that the Neolithic Revolution precipitated deeply significant changes, not only in the life histories of human populations related to reproduction and health issues, animal husbandry and the development of cultigens but also a shift in gender discrimination and perceptions of the supernatural. The Neolithic Revolution initiated, and eventually led, to the establishment of modern monocultures dominating vast tracts of land and, through time, increasingly decimating the natural biodiversity of the planet.

If hunter-gatherers were obliged to embrace agriculture because they were experiencing population stress and climate change, they probably gained more than they forfeited,

because in spite of the negative impact of sedentism, increased production of food led to surpluses and population growth. From an evolutionary perspective, the primary currency of success is vested in the numbers of fertile offspring attaining reproductive status. Therefore, by driving exceptional population increases and precipitating severe health issues, farming also served as trigger to shorter birth intervals. The Neolithic Revolution was therefore the predominant impetus behind the eventual development of cities and states, hugely changing human settlement patterns over time. Continual fine-tuning of farming methods further increased yields, which led to surpluses, wealth and more free time, thus facilitating a range of additional human accomplishments, including an increase in the production of art, the development of writing and literature, as well as achieving milestones in technology, followed by the incipient development of scientific rationality. Thus, the transitions caused by agriculture were hugely significant, extensive, complicated and multifaceted. The outcomes still resonate in modern societies in the domains of health, social agendas, economics and even politics.

'The other side of the coin, however, is that farming surpluses also made possible social stratification, hence oppression, slavery, war, famine, and other evils unknown to hunter-gatherer societies' (Lieberman 2013:203). The compelling model of Wells and Stock (2020) offers a way of rationally evaluating the various life-history trade-offs in human populations through time. Their data reflect how fundamental permutations in energy allocation to reproduction and defence are indicated by population growth, despite higher incidences of infectious diseases. In retrospect, we can surmise that if the egalitarian hunter-gatherer communities had persisted to the present, untold millions of people and other organisms would not have succumbed to plagues, malnutrition, starvation, religious wars and chemical toxicants. This, however, is wishful thinking, because despite all these vicissitudes, more than 8 billion people currently call planet Earth home, something that would have not been possible had we remained hunter-gatherers and the Agricultural Revolution never occurred. Thus, like falling dominos, the consequences of the Agricultural Revolution have swept through the preceding millennia, right up to the present, and despite all our scientific and technological achievements, detailing the inherent problems and advances, we still have not achieved effective ways of managing this juggernaut. However, these are the life and times of modern humanity, and we have to accept and deal with the fallout as best we can.

In the final analysis then, the inevitable question that demands our attention is whether the ubiquitous flowering of agriculture since the beginning of the Neolithic constitutes an indispensable and worthwhile series of events in the recent history of *Homo sapiens*. Here we defer to Lieberman (2013:203): 'In effect farming made civilization possible'.

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