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Yeast, coal, and straw: J. B. S. Haldane's vision for the future of science and synthetic food

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Abstract

British biologist and science populariser J. B. S. Haldane was known as a contrarian, whose myriad ideas and beliefs would shift to oppose whomever he chose to argue with. Yet Haldane's support for synthetic food remained remarkably stable throughout his life. This article argues that Haldane's engagement with synthetic food during the 1930s and 1940s was shaped by his frustration with the status and direction of scientific research in Britain. Drawing upon the Haldane Papers, I reconstruct how Haldane's interest in synthetic food emerged from the biochemical and physiological optimism of the early 20th century. His mid-20th-century writings were an opportunity for Haldane to voice his political opinions. He attempted to erase the conceptual divide between farm and factory, maintained that food shortages were a capitalist construct, and criticised British colonialism. By pointing out the failure of existing economic systems and governments to develop synthetic food, Haldane made the case that food production should be placed under the control of biologists.

Keywords

agriculture, Haldane (J. B. S.), Marxism, population, synthetic food

Introduction

It was 'complete nonsense', according to John Burdon Sanderson (J. B. S.) Haldane (1892–1964), that the 1944 Royal Commission on Population had suggested that a

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rapid increase in Britain's population would leave the nation unable to 'sustain life'. While traditional agriculture may not be up to the task of supporting a growing population, synthetic foodstuffs made from raw materials like wood or coal could. 'It is very expensive to make [synthetic foods]', acknowledged Haldane. 'The amount of research which was put into making atomic bombs would certainly allow us to make many of them, perhaps all of them, quite cheaply.'[1] This critique of the Royal Commission reflected several aspects of Haldane's character. As one of the Cambridge-educated 'Red Professors' of the 1930s, the famed British biologist, Marxist, and populariser of science was a critic of Malthus and the British state's troubled relationship with science (Werskey, 1978). Over the course of his career, Haldane would strongly advocate for a synthetic diet, promoting proteins and sugars extracted from raw materials or food substitutes like yeast. By the mid 20th century, synthetic food was integral to his critique of capitalism and colonialism. Haldane would urge his readers to look forward to a future where a hungry world would be fed synthetic food produced in communist factories.

Haldane's colourful life has led to numerous treatments in the scholarly literature, including three biographies (Clark, 1968; Dronamraju, 2017; Subramanian, 2020). His contributions to science, largely in genetics and evolution, have also been the subject of multiple works (Adams, 2000; Fara, 2004; Sarkar, 1992a). We know that Haldane was directly involved in agriculture and breeding through the John Innes Horticultural Institution from 1927 to 1937 (Harman, 2004; Wilmot, 2017). He simultaneously clashed with the interwar Malthusian movement, which at the time was strongly associated with eugenics (Allen, 1991; Bashford, 2007; Chase, 1977; Connelly, 2008; Robertson, 2012). Scholars have also demonstrated that the 20th century saw the 'suppression of variation and the purification of the natural by its substitution with the artificial', a trend 'central to twentieth century experimental design in the life sciences' (Landecker, 2016: 158). This ambition included food, as cultivated organisms were kept in synthetic mediums and laboratory animals fed synthetic diets (ibid.: 153). Individual components of food, notably vitamins, were found to be integral to both the health and inner metabolism of the body (Braun, 2011). Despite this literature, however, Haldane's long-standing support of synthetic food has yet to be thoroughly examined.

This article argues that Haldane's support for synthetic food was shaped by his frustration with the state of scientific research in Britain. Haldane originally embraced synthetic food in the context of early 20th-century biochemical and physiological optimism. Yet his continued support over the decades was driven by other political and social factors: his desire to improve the social status of science, his experience of wartime blockades and food shortages, and his conversion to Marxism. These factors were inseparably linked. During the 1930s, many British scientists were alarmed by the Great Depression and the rise of fascism. Some sought refuge with socialist or communist ideology, 'impressed by the special role assigned to science in Marxist ideology and the Soviet state'. To these scientists, most notably Haldane, 'the development of socialism was always explicitly connected with scientific and technical advance – whereas it seemed that capitalism actually put a brake on scientific progress wherever it conflicted with vested economic interests' (Filner, 1977: 305). As the middle of the

20th century approached, Haldane did not engage with scientific developments in the creation of synthetic food. His description of how synthetic food might one day be produced was no different from that which he had originally envisioned in the 1920s. Instead, he used the issue of food production to argue for an enlarged role for scientists in society and to attack various aspects of capitalism and the British state.

To reconstruct Haldane's wide ranging contributions to debates about synthetic food and related discussions on population, agriculture, and science, this article is divided into three parts. Firstly, we will trace early influences on Haldane's support for synthetic food, which he first expressed in his 1923 essay *Daedalus*. From his father, the physiologist John Scott Haldane (1860–1936), Haldane gained an admiration for practical science and later developed the analogy between the human body and machines such as motor cars. At the Biochemistry Laboratory in Cambridge, he adopted the mechanistic perspective of British biochemist Frederick Gowland Hopkins (1861–1947). This relationship would both bring Haldane into contact with the 'synthetic method' and expose him to chemical and mechanical recreations of biological systems. During the 1920s and early 1930s, Haldane moved closer to Marxism and became increasingly alarmed by the prospect of food shortages during wartime blockades. Secondly, we will examine how Haldane 'marketed' synthetic food to a popular audience in his books and articles for the *Daily Worker* newspaper. He would argue against Malthusian limits and describe national defence as a biochemical problem. Among his strategies for making synthetic food more palatable was blurring the divide between natural and unnatural food, or between the farm and the factory. Finally, we will explore how Haldane's support for synthetic food tied into his politics. By the mid 20th century, his support for synthetic food was closely tied to his Marxism. Haldane saw food shortages as an artificial creation of the capitalist system. He criticised British colonialism and advocated placing control of food production into the hands of biologists. This last point was key, as Haldane firmly believed that synthetic food would become a reality only when scientific policy was guided by scientists themselves.

Artificiality and substitution

In *Daedalus*, an infamous paper read before the Cambridge Heretics Society in February 1923, a 30-year-old J. B. S. Haldane identified a series of prehistorical 'biological inventions', including fermentation and the domestication of plants and animals.[2] He described these innovations as a kind of perversion of religious or natural law. 'We have only to imagine ourselves as drinking any of its other secretions', wrote Haldane (1923: 45) of consuming dairy, 'in order to realise the radical indecency of our relation to the cow'. Haldane also suggested that the application of chemistry or microbiology would one day produce inexpensive sugar and starch. Protein could be synthesised from coal or atmospheric nitrogen. 'I should be inclined to allow 120 years, but not much more', predicted Haldane (ibid.: 38), 'before a completely satisfactory diet can be produced in this way on a commercial scale'. He also railed against what he saw as the innate conservatism of agricultural societies. 'It took some thousands of years to produce the stable agricultural society which forms the basis of European life', he complained, 'and whose morals we are too apt to regard as eternal truths' (ibid.: 22). The development of synthetic

food would one day replace the agricultural labourer with the factory worker, a transformation that Haldane saw as highly desirable. 'Human progress in historical time', Haldane (ibid.: 39) wrote, 'has been the progress of cities dragging a reluctant countryside in their wake'.

Haldane's early advocacy of a synthetic diet was originally rooted in the biochemical optimism of the early 20th century. Two figures were instrumental in Haldane's embrace of synthetic food. The first was his father, the physiologist John Scott Haldane. Haldane Senior embodied science in its 'purposeful, utilitarian mien', working on health and ventilation in the slums of Dundee and investigating mining accidents (Subramanian, 2020: 53). Food and nutrition (or lack thereof) would have been noticed by Haldane Senior during his health and sanitation work in urban slums. His son was effectively born into the scientific life, imitating and assisting his father. The young Haldane encountered biology and genetics at an early age, attending a talk on Mendelian genetics by the biometrician Arthur Darbishire at the age of eight (ibid.: 63). The First World War may well have also sparked an interest in agriculture and food security. Haldane would later recall that British food shortages during the war were not as serious as those, for example, in Holland or Poland. There were, however, outbreaks of scurvy in Glasgow, Manchester, and Newcastle.[3]

In *Possible Worlds and Other Essays*, Haldane (1927: 186) would link inadequate diets to physical ailments and poor dental health. He admitted that 'nothing out of a tin or package so far comes up to natural foodstuffs', but also recognised that nutritionally superior 'natural' food was not available to the impoverished populations of large cities. It was therefore up to scientists to 'determine what can be done to improve a diet based largely on milled cereals and tinned milk and meat'. Haldane had great faith in the ability of scientists to manage food production and distribution. This faith was, at least in part, based upon his perception of rationing in the First World War. If rationing had been left to politicians, argued Haldane, waste and dietary deficiencies would have been inevitable. There may not have been outright starvation, but diseases like scurvy and rickets would have ravaged British cities. Thankfully, wrote Haldane, 'the politicians took the advice of some very competent biochemists, and rationing was a success' (ibid.: 186). Haldane would always return to his father as an example of how scientists could serve society. 'My father's work', he declared in 1942, 'which led simultaneously to the saving of thousands of miners' lives and the discovery of how breathing is regulated is an example of what might be and what will be when the internal contradictions of our existing society have been abolished'.[4]

At the age of 17, Haldane presented his first scientific paper to the Physiological Society. Throughout his childhood, he had acted as a human guinea pig during his father's investigations, experiencing the physiological effects of deep-sea diving and noxious gases in mines. From these experiences arose a tendency for self-experimentation. Haldane would repeatedly compare the living body to a motor car. 'If we compare the requirements of an animal and a motor vehicle', he wrote in *Possible Worlds*, 'water serves the same function in both, of cooling and carrying away unwanted substances, carbohydrates and fats correspond to petrol, proteins to spare parts, and probably vitamins to lubricating oil' (Haldane, 1927: 65). Speaking of a seemingly unhinged decision to consume ammonium chloride for an experiment, Haldane explained that it only 'appeared unusually brave because we are accustomed to think in an accurate and

materialistic manner about motor-cars but not about ourselves'.[5] In terms of physiology, then, Haldane had no difficulty comparing the body to a mechanical system with specific inputs and outputs. On some level, this analogy undoubtedly served as a psychological aid when undertaking some of his more dangerous self-experiments. He described the attitude of his father towards danger and suffering in science as 'much like that of a good soldier who will risk his life and endure wounds in order to gain victory' (Clark, 1968: 5).

Haldane's comparison between the living and artificial became more pronounced under the tutelage of a second inspirational figure. In 1923, Haldane accepted a position at the new Biochemistry Laboratory at the University of Cambridge, under the biochemist Frederick Gowland Hopkins. Hopkins was 'an ardent advocate of mechanistic explanation and, indeed, of a mechanistic materialism' (Sarkar, 1992b: 389). This philosophical atmosphere was quite different than that which Haldane was used to. His father was a supporter of 'holism' or 'organicism' in biology and an admirer of Kantian teleology (Sturdy, 1988: 325). Haldane admitted that his own ideas on physiology had been shaped by his father and the *milieu intérieur* of French physiologist Claude Bernard, which described how an organism maintained a stable 'internal environment' under different conditions (Holmes, 1986). Yet Hopkins left a 'profound effect on Haldane's philosophical development' (Sarkar, 1992b: 389). At the Cambridge Biochemistry Laboratory, Haldane turned to a 'metabolic' approach to physiology, which sought to give 'material biochemical explanations' of the processes by which biological phenomena such as pigmentation in plants arose (Sarkar, 1992a: 54).

In *Possible Worlds*, Haldane (1927: 51–2) gave a potted history of biochemistry, in which he would describe Hopkins as the most successful advocate of the 'synthetic method'. This method asked whether it would be possible to 'make a complete diet out of substances of known chemical composition'. Contemporary definitions of *synthetic* show that the term could be used to denote materials created in a laboratory setting by chemists seeking to replace 'natural' products with 'artificial' substitutes (C., 1923: 930). Within biology, however, a 'synthetic product' could also refer to a substance like adrenaline, which is 'synthesised' by the body using the basic molecules available from digested food (Raper, 1930). A synthetic diet could therefore include artificial substances (such as protein made from coal) but might also merely consist of the most chemically simple foods available (such as yeast acting as a protein substitute for meat and dairy). Haldane (1927: 52) went on to list some of the recent achievements of biochemistry, which included the discoveries of iodine and zinc deficiencies and vitamins, for the latter of which Hopkins was awarded the Nobel Prize in 1929.

In *Daedalus*, released the same year that Haldane joined Hopkins' laboratory, Haldane expressed the belief that the constituent components of food could one day be isolated and artificially produced. In *Possible Worlds*, he would blur the boundaries between the artificial and the natural still further. Haldane (1927: 45) gave his readers two examples of how the chemical processes in living things could be 'imitated by artificial means'. The first was an artificial cell created by German zoologist Johann Ludwig Rhumbler (1864–1939). In the early 20th century, Rhumbler had attempted to give a mechanistic account of cell development (Wellmann, 2018: 5). One of his experiments, explained Haldane (1927: 45), demonstrated how an artificial cell could absorb a glass thread

covered in wax, remove the wax, and expel the thread. The second example was 'Seleno', an automaton made by John Hays Hammond Jr and Benjamin Franklin Miessner. This 'electric dog' possessed artificial eyes made with selenium, which could trace a light or white object. Its electric motors would allow it to follow light sources around a room. Haldane (ibid.: 45) also noted that the internal processes of a cell could be artificially reproduced with chemicals. He acknowledged, however, that these chemical reactions were far more violent than their natural counterparts.

Shortly after the publication of *Possible Worlds*, Haldane received an invitation to visit the Soviet Union from the botanist Nikolai Vavilov (1887–1943). When Haldane visited in 1928, Vavilov arranged for him to give lectures on genetics in Leningrad and Moscow. Haldane was charmed by the hospitality of the Russian botanist and was inspired by the Soviet state's attention to scientific matters (Subramanian, 2020: 12). He 'regarded the high position accorded to scientists in Soviet society as their [the Soviet Union's] most outstanding characteristic' (Dronamraju, 2017: 168). Besides a certain admiration for the science and society of the nascent Soviet Union, Haldane may have taken away other ideas from his encounter with Vavilov. The importance of history and its application to science, or what Haldane would later term 'the historical angle', was one such lesson. Following his embrace of Marxism, Haldane (1947: 210) would use Vavilov's research as an example of how science – inspired by the philosophy of dialectical materialism – could shed new light on human history. Described as the 'Mendeleev of biology', Vavilov would compare biology to the periodic table by attempting to fill gaps in botanical knowledge with 'plant forms that featured some combination of traits that must exist but had yet to be discovered in nature or created artificially' (Aronova, 2021: 69).

In a lecture on political philosophy delivered at the University of Birmingham in early 1938, Haldane (1939: 1) would claim that he had 'only been a Marxist for about a year. I have not yet read all the relevant literature, although I had of course read much of it before I became a Marxist.' In his 1942 autobiography, he implied that he had read the philosophy of Marx and Engels at New College, Oxford, where he studied from 1919 to 1922.[6] In 1937, his wife, Charlotte Franken, had become a member of the Communist Party of Great Britain. Several aspects of Marxism appealed to Haldane on a personal level. The philosophy was areligious and 'privileged practice over theory' – something that Haldane, as a boy, had seen his father do in his own field (Subramanian, 2020: 169). Synthetic food would become part of Haldane's growing political convictions.

Before his official conversion to Marxism, Haldane had already begun to critique capitalism and portray synthetic food as a disruptive technology. In *The Inequality of Man*, Haldane (1932: 130–1) argued that 'Socialism would be very considerably less dysgenic than the capitalism under which we live', primarily because Western civilisation had failed 'to integrate into its intellectual structure the scientific ideas which have furnished its material structure'. Synthetic food would expose this failing. Haldane (ibid.: 131) believed that 'the production of synthetic food on a commercial scale' would occur during the lifetime of his readers. It would include the production of fats and oils from coal and other minerals and the extraction of sugar and starch from wood pulp and straw. The 'ruling classes' in the West, observed Haldane, were completely unprepared for the consequences of the synthetic food revolution. If left unchecked, synthetic food

technology would be 'exploited by individual rich men, or individual States', leading to dislocation, revolution, and war (ibid.: 131).

As the decades passed, Haldane's support of synthetic food would rest more upon his politics than science. A part-time appointment at the John Innes Horticultural Institution from 1927 to 1937 brought Haldane into contact with the realities of plant breeding. Yet the encounter was not scientifically fruitful, with the mathematically inclined Haldane having 'little in common with his colleagues' working methods' (Wilmot, 2017: 818–19).[7] During the 1930s, nutrition science saw a renewed drive to produce synthetic diets for laboratory animals (Landecker, 2016: 153). Yet Haldane seemingly took little notice of interwar work in amino acids or vitamin content in animal diets. Instead of discussing the latest science behind synthetic food, Haldane would instead focus his attention on 'human' factors: explaining why we should be unafraid of synthetic food and what benefits it would bring to society.

Population and war

'When – not if – we can separate the cellulose-splitting enzymes from those which break up the sugar further', explained Haldane (1927: 49–50), 'we shall be in a position to convert wood pulp or hay quantitatively into human food'. 'This', he continued, 'is one of the facts which render dubious all prophecies as to over-population. The upper limit to human numbers is not set by any facts of nature, but by human ignorance and inadaptability.' Although Haldane believed that food produced in a laboratory or factory would be no different to that produced on a farm, there was still the matter of convincing others that a synthetic diet was at all desirable. Haldane did attempt to live by his synthetic food creed but admitted that it was not for everyone. 'One can replace a good deal of meat and cheese by yeast', he explained in his autobiography, 'but I am one of the very few people who eat it regularly'.[8] Haldane's father had always avoided using animals in his experiments wherever possible, while Haldane himself would gradually move towards vegetarianism following his move to India in 1957 (Clark, 1968: 141). If synthetic food were ever to be embraced, he would need to argue that humanity must accept substitutes like yeast. A growing world population would give Haldane one rationalisation for the introduction of a synthetic diet.

In a lecture at Columbia University in January 1935, Haldane showed himself to be very much on the side of human agency and against the idea of 'biological laws' – notably the Malthusian limits to growth – dictating human affairs. He began his lecture by positioning himself against those who believed that the world population was growing to unbearable levels, notably the American botanist and eugenicist Edward Murray East (1879–1938). In his book *Mankind at the Crossroads*, East (1923) had argued that the finite amount of farmland in the world would fail to supply a rising population. Unlike other Malthusian thinkers, he emphasised the dangers of falling soil fertility and environmental damage, recommending soil conservation, birth control, and strict limits on immigration (Robertson, 2012: 240–1). In the United States, eugenics was closely intertwined with agriculture and capitalism, reflecting a 'larger popular belief in biologically reproduced hierarchy and the state's capacity to govern it' (Rosenberg, 2020: 387). By the 1930s, Haldane had no patience for eugenic

regulation or control of human populations. At Columbia, he attacked those concerned by falling birth rates among white Americans. If they were genuinely concerned by this trend, argued Haldane, they should look away from biology and towards economics. If children were too expensive to have, birth rates would fall. 'Today children are not being born largely because, instead of being an asset', remarked Haldane, 'they are a liability. That would be the Marxist point of view.'[9]

Haldane also used his Columbia lecture to puncture the overpopulation trope. He dismissed the argument that contemporary food shortages were inevitable or unavoidable. 'It is now an elementary fact', claimed Haldane, 'that there is more food in the world than can be eaten under our present economic system'.[10] Capitalism, not Malthusianism, led to hunger. On the argument that global population trends would lead to too many mouths to feed, Haldane observed that birth rates were generally falling, leading to the seemingly paradoxical situation that 'the population of your country [the United States] is increasing and yet not enough children are being born to replace their parents'.[11] He was also of the firm opinion that agriculture could be improved or expanded, blaming the Japanese struggle to feed a growing population on their 'primitive' agricultural system. After the First World War, noted Haldane, German scientists had 'chewed the seeds of a million and a half [wild] lupin' to find those which were palatable. Using these seeds, they hoped to turn sandy soils into fields of edible lupin that could support livestock.[12] Human ingenuity could always provide fresh sources of food or agricultural land.

The spectre of the First World War – and the possibility of a second – loomed over Haldane's Columbia lecture. A few months before his visit to the United States, Haldane recalled, he had been asked to give a topical radio address on the causes of war. 'I took the view', he quipped, 'that there were not any biological causes of war and that there had not been a country with thoroughly biological causes of war since the Trojan War, which I believe was fought on a biological issue'.[13] The British Broadcasting Corporation did not air the interview. Yet the contrarian Haldane seemed to delight in this supposed censorship, repeatedly returning to the story of his failed interview. In it, he claimed to have made the argument that food surpluses would promote peace. 'In 1934 the BBC asked me to join in a discussion on the causes of war', he recalled. 'I said that one possible cause was our unpreparedness, and that if we had three years' supply of wheat in the national granaries, and a system of air-raid shelters, no one would be likely to attack us.'[14] In an unpublished autobiography written in 1942, Haldane would date his interest in population to the 1920s, when he attempted to apply mathematical principles to animals. He also went so far as to describe 'the national defence of Britain' as a 'largely biochemical problem'.[15] In Haldane's mind, modern warfare was conducted through blockades and aerial bombardment. If Britain had the ability to feed its population with synthetic food, blockades would be ineffective and would-be attackers deterred from waging war in the first place.

Shortly after his intervention into the population debate at Columbia University, Haldane gave a 1936 talk entitled 'Plants and Animals in Human History'. In it, he compared the domestication of plants and animals to the invention of the steam engine and the Industrial Revolution as milestones in human history. 'When we look back at the past', noted Haldane, 'we are apt to think that when most of the people lived on the land

as farmers or in close connection with the farm, they were leading a natural life'. Such reasoning, according to Haldane, was 'nonsense'. 'A farm', he declared, 'is as unnatural as a motor bus or a blast furnace'. Farmers cleared trees and eliminated weeds in order to raise 'most unnatural plants such as wheat and potatoes', or 'unnatural animals like cows'. When considering human history in its entirety, agriculture was a recent invention. For hundreds of thousands of years, declared Haldane, 'man had been a hunter like the men of the old stone age who hunted the wild horse and the mammoth, or a food gatherer like those other stone age men who left great mounds of oyster and mussel shells on the coast of Denmark'.[16]

This 1936 talk was part of a wider argument for synthetic food. Haldane had long derided those who saw a difference between a 'natural' and 'artificial' diet. Repeating a point first raised in his essay *Daedalus*, Haldane (1923: 45) described the consumption of milk and fermentation of cheese as thoroughly unnatural by any standard. 'But if anyone says it is unnatural to eat food not produced in the traditional way', Haldane continued, 'they had better start chewing wheat grains and tearing up raw rabbits with their teeth'.[17] The aim of this rhetoric was clearly to overcome public hesitation toward eating food derived from such odd sources as coal and grass. He also believed the countryside was long overdue an economic and technological revolution. In his mid-20th-century essay 'Our Food Production Methods Date From the Stone Age', Haldane imagined the reaction of a man 'buried in a barrow on Salisbury Plain [a Neolithic burial site] three or four thousand years ago' who found himself resurrected in post-war Britain. Some aspects of the modern world would be alien or frightening. A factory, for instance, would be beyond his comprehension. 'He might think a motor bus was an animal', mused Haldane, 'because it moved itself'. The Neolithic visitor would also be surprised by a visit to a modern farm, with its machinery, vast fields of uniform wheat, and large dairy cows. Yet, pointed out Haldane, he would still understand what was going on around him. 'He would not see a single food plant or animal which had not already been domesticated in his time', argued Haldane, 'though pigs, poultry, and potatoes had not yet arrived in Britain'.[18]

The years leading up to the Second World War had heightened Haldane's political activism. He travelled to Spain during the civil war as an advisor for the Republicans and stated that his embrace of communism was thanks to 'Adolf Hitler and Benito Mussolini, who converted me to cooperation – after softer arguments had failed'.[19] Marxism supported Haldane's view of life, which was largely mechanistic (albeit with some important caveats). In *The Marxist Philosophy and the Sciences*, he stated that 'our analysis of a living organism is only likely to be satisfactory if it starts off with a recognition that this mechanistical interpretation is of very great value, that Descartes did a very great thing for physiology' (Haldane, 1938: 102). Of course, the human body was complex, dynamically interacting with its environment and possessing internal regulatory systems. This caveat to a purely mechanistic account of life was held by Haldane's father. Yet on a practical level, a mechanistic account of the body worked. 'Many physiologists found my father's theories rather difficult to follow', wrote Haldane (ibid.: 104), 'but they found that his practice was fairly easy to imitate, given sufficient technical skill'. One example was his father's shift from studying how blood carries gases to producing a mechanistic account of how breathing worked.

This mechanistic method 'worked pretty well' without requiring any reference to vitalism (ibid.: 104).

The 1930s saw Haldane laying the groundwork for his mid-20th-century advocation of synthetic food. At Columbia University he spoke out against Malthusian limits, highlighting the potential of plant breeding, fertilisers, and other farming technologies. Human ingenuity and inventiveness, he argued, could overcome hunger. Haldane would go on to compare farms to more explicitly 'artificial' technologies like cars and furnaces, while simultaneously stating that a new agricultural revolution was long overdue. These talks and essays further blurred any distinction between the artificial and natural, in effect removing the conceptual boundary between synthetic and farm-produced food. Haldane's picture of a Neolithic farmer recognising elements of his own life in modern agriculture also tells us that Haldane viewed traditional forms of agriculture as hopelessly outdated. Haldane's adoption of Marxist philosophy, meanwhile, reinforced his mechanistic view of the body. We can also speculate that the Spanish Civil War renewed Haldane's concerns over wartime food shortages. 'I have seen the effects of blockade on the children of Spain', he would later recall, 'and regard it as one of the most inhuman of all war measures' (Haldane, 1940: 161). As the mid 20th century approached, Haldane would engage with synthetic food as a solution to the problems facing Britain and the wider world.

The politics of synthetic food

Due to fear of air raids, at the outbreak of the Second World War Haldane and other London-based scientists were evacuated to Rothamsted Experimental Station, an agricultural research institute. Here, Haldane took up much of a shared preparation room with a large steamer, which he used to sterilise bottles in preparation for genetic experiments on *Drosophila* fruit flies (Nutman, 1994: 25–6). When his first wife, Charlotte Franken, returned from a visit to the Soviet Union in 1942 with the news that the botanist and geneticist Nikolai Vavilov had been arrested and executed, Haldane steadfastly refused to believe her (Subramanian, 2020: 223). Haldane would spend much of the 1940s embroiled in the 'Lysenko controversy', with his apparent support for the controversial biology and politics of the Soviet Union coming under intense scrutiny from fellow scientists (DeJong-Lambert, 2012; Harman, 2003; Teich, 2007). Following the Second World War, Haldane was in high demand from agriculturalists, with the British Cattle Breeders' Club approaching him in 1948 to ask for advice on breeding and genetics.[20] Haldane even dabbled with the idea of creating a farm to produce experimental organisms for biologists.[21] Yet he still found time to develop his thoughts on synthetic foods, largely in the pages of the communist newspaper, the *Daily Worker*.

It had been decades since Haldane predicted the development of synthetic food in *Daedalus*. By the mid 20th century, synthetic food had become one of his political projects. The fact that major milestones had not been reached in its development was, to Haldane, an indictment of the poor relationship between Western capitalist nations and science. 'Every year more people are becoming disillusioned with science', he wrote, 'for the very good reason that science is not being used to give them what they need'. Instead, societies spent 'colossal sums' on research into new weapons, or 'the production

of new luxuries such as television and nylon'. This misappropriation of scientific resources was even more mind-boggling when food shortages still existed. The fact that thousands of people died every year from starvation in Asia, argued Haldane, was the case only because 'mankind has refused to use scientific knowledge for food production'.[22] He had criticised the British government's lack of support for science and its inadequate research system, which he thought could be improved only through 'a combination of planning and democracy', which were 'incompatible under capitalism'.[23] British science also made too great a distinction between pure and applied research, a distinction that Haldane claimed did not exist in the Soviet Union.

Haldane's commitment to Marxism and his vision of a future society led by science were deeply entwined. His visit to the Soviet Union in 1928 had convinced him that a Marxist society held science in higher esteem than its capitalist counterparts. During the 1940s, Haldane sought to strengthen the relationship between Marxist philosophy and the sciences. In an introduction written for a new issue of Frederick Engels' *Dialectics of Nature* (1940), Haldane praised Engels' grasp of 19th-century science. In his own work, Haldane claimed that some of the paradoxes he encountered during his research in population genetics were resolved only when he turned to Engels' 'dialectical terminology'.[24] Perhaps more importantly, Haldane's reading of Marxist philosophy convinced him that this was an ideology wedded to the importance of technology and technological progress. He opened one *Daily Worker* article on the Marxist approach to prehistory by arguing that an individual's scientific work could not be disconnected from their philosophy or politics. He characterised Marxist science as being particularly interested in 'change' and 'transformation'. In archaeology, according to Haldane, the influences of race, religion, and language were all overruled by the importance of technological artefacts. If Marxism had already had 'a great and fruitful influence on the study of primitive human societies', there was no reason it should not be introduced to other fields of scientific endeavour, or directed towards questions concerning contemporary society.[25]

For Haldane, synthetic food, produced in the laboratory or factory, represented the future. He continued to insist that sugar could be manufactured from sawdust, or that yeast would one day replace meat and cheese. Some of the chemical constituents of food would also be acquired through the processing of non-organic materials such as coal and limestone. The 'antiquated character' of traditional agriculture would disappear, with future improvements to food production resembling the infrastructure upgrades applied to transport, buildings, or the textile industry. This technological revolution in agriculture would likely occur in parallel with a political revolution. 'The necessary research cannot, like a lot of chemical and engineering research', argued Haldane, 'be done by private enterprise. For it would not pay.'[26] The state would have to shift its resources and attention away from weapons and commodities to food production. Haldane believed that such a realignment would make Britain self-sufficient, with the ability to export food where it was needed. If sugar could be made from starch, wrote Haldane, Britain would be able to feed itself for several years. Yet he did not delude himself that a biochemical approach to national defence was ever a realistic possibility. 'Such an invention is not a likely source of profit to anyone', remarked the Marxist Haldane, 'so noone is working on it, and if a lot of us starve to death in the next war,

that will be just too bad'.[27] Wartime shortages were no different from other food shortages. They were a matter of bad policy, not inevitable natural laws, or Malthusian limits.

Haldane's synthetic vision for the future of agriculture was tied into other aspects of his politics, particularly his anti-imperialism. As a student, he had taken a traditional literature and humanities course at New College, Oxford, later remarking that this education produced only amoral civil servants 'prepared to report as unemotionally on the massacre of millions of African natives as on the constitution of the Channel Islands'.[28] In 1942, he lashed out at the British archaeologist Christopher Hawkes, centred at the Department of British and Medieval Antiquities in the British Museum (Díaz-Andreu, Price, and Gosden, 2009). While at Rothamsted, Haldane had heard a second-hand account of one of Hawkes' papers on the development of European civilisations. 'I disagree with your biology', stated Haldane. 'You seem to regard races as made up by a mixture of more or less invariable components like chemical mixtures or compounds.'[29] Apart from the clustering of blood types, argued Haldane, the physical characteristics we associate with racial groups were in a continuous state of change from selection, mixing, and diet. Hawkes quickly replied to exonerate himself of these charges. He had been speaking as a 'prehistorian' reliant on archaeology about different cultural groups, 'the crude equation of which with races is quite unscientific'.[30] This exchange depicts a Haldane keen to oppose arguments for scientific racism or eugenics (Dronamraju, 2017: 65; Esposito, 2011: 41). In a 1948 response to a 'Comrade J.A.P. Hall', Haldane rebuked those who believed that habits or behaviour could be transmitted down the generations by some biological mechanism. 'Perhaps I have an emotional bias on this matter', he confessed. 'For it has been argued that primitive human peoples require many generations of tutelage by more civilized ones before the habits of civilization become ingrained in them, and they can be trusted to look after themselves. I do not believe this.'[31]

Imperial ambitions, in addition to their inherent cruelty and racism, also held back scientific progress. Haldane suggested that one of the reasons that the British government would probably not embrace his drive for synthetic foods was that it had already 'spent so much money on ill-advised schemes of colonial development'.[32] In the early 1940s, the British Colonial Office had departed from its standard policy and announced 'that it would promote industrial development in Britain's colonies' to counter unrest and unemployment (Clarke, 2018: 76). This scheme involved funding scientists to find new industrial materials and processes, including the creation of new plastics and drugs from agricultural products like sugar cane. In addition to his general anti-imperialism, Haldane was probably unimpressed by the Colonial Office's plan to use scientists to 'discover new products or processes' in the hopes that the 'business world would take them up' (ibid.: 106). When it came to food production, Haldane supported a much-reduced role for private enterprise. Nor was he impressed when the British state did become involved in agriculture, citing the infamous 'East Africa groundnut scheme' as an example of misplaced government expenditure (Westcott, 2020). If biologists had been consulted on the groundnut scheme, he claimed, 'they would have saved us many millions of pounds'. Haldane asked his readers to trust scientists, arguing that sceptics of synthetic food would have been the same people who once cast doubt on the railways or powered flight. 'Give us biologists a free hand with food production', declared Haldane, 'and

we will give you a world in which there is enough food for everyone'.[33] If nations like Britain did manage to become self-sufficient using synthetic food, they would not need to rely on colonies to supply them.

If Haldane had his way, then the traditional farm would be removed from human life entirely. Some major technical obstacles, however, remained to be overcome before a synthetic diet would be at all viable. In another mid-20th-century essay, Haldane addressed the scientific challenges in manufacturing sugar or extracting nutrients from grass and coal. Some molecules, including those of sugar, were unfortunately asymmetrical. If you produced sugar in a laboratory, therefore, only half of it was of any use to living things. 'If Alice found looking-glass sugar when she went through the mirror', explained Haldane, 'she could not digest it. Still less could she cope with the looking-glass meat or cheese. But she could digest looking-glass butter or fat.'[34] This account was not based on new information. As far back as *Possible Worlds and Other Essays*, he had used the image of Alice in her world of opposites to illustrate the problem of asymmetrical molecules in laboratory-made sugar. On 'going through the looking-glass', Haldane (1927: 46) explained, 'Alice would have found her digestive enzymes of no more use on the looking-glass sugars than her Yale key on the looking-glass locks'. Although the political and social rationale behind the development of synthetic food had expanded considerably, Haldane's description of the science remained much the same. His predictions for what form synthetic food would take remained rooted in the physiological and biochemical optimism of his youth.

Haldane acknowledged that the scientific and political barriers to producing synthetic food were considerable, but he had no doubt that they would one day – possibly in the far future – be overcome. He predicted that synthetic food would eventually be a moral necessity, as 'remote future men and women will have so much respect for life that they would no more think of eating a dead animal than a dead man, and will prefer not even to kill plants for food'. In an era of renewed concern over population growth, notably expressed through eugenic and ecological thinkers such as Frederick Osborn and William Vogt, Haldane urged his readers not to give in to despair (Connelly, 2008). 'Meanwhile', he wrote, 'let's have done with this defeatism about food production, and start trying to make Britain self-supporting'.[35] Although Haldane did not engage much with contemporary scientific developments in producing a synthetic diet, he was aware that laboratory-made materials were replacing their natural counterparts. Synthetic fibres such as nylon and vinyon, for instance, were replacing silk and rayon (itself a semi-synthetic fibre). Haldane (1947: 71, 189) even remarked that experiments in domesticating animals, like the silver fox in the Soviet Union, would not last for centuries as furs would be replaced by synthetic fibres. If fibres were gradually becoming synthetic, there seemed to be no reason that food would not follow.

Arguing in favour of synthetic food acted as a kind of focal point for Haldane's long-held grievances. He could attack global food shortages and failed colonial development schemes, all the while pointing out the capitalist neglect and misalignment of science. A synthetic future also contributed to Haldane's communist beliefs. Removing traditional farms and replacing them with factories or laboratories, for example, would also remove the distinction between city and countryside, derided by Marxists as an irrational artefact of capitalism (Patterson, 2003: 62). Perhaps more importantly, however, the

struggle to develop synthetic food aligned with Haldane's cynicism of British institutions and their relationship with science. His political shift towards Marxism and the Soviet Union had been driven in part by a perceived lack of respect for scientists (Subramanian, 2020: 166). In the late 1920s, Haldane had despaired at the number of biochemists languishing on the job market without work, although they were needed in fields such as medicine.[36] Science, believed Haldane, was underfunded and unappreciated by all aspects of the British establishment (ibid.: 163). Synthetic food was yet another example of how science was maligned in the West.

Conclusion

Haldane was an infamous contrarian, whose myriad ideas and beliefs would shift to oppose whomever he chose to argue with. One friend remarked that 'Haldane may be said to be a Conservative when he is in the company of Socialists and a Socialist when he is in the company of Conservatives' (Clark, 1968: 109). Despite his mercurial nature, Haldane's support of synthetic food remained remarkably consistent throughout the 20th century. It was originally born from biochemical optimism. Drawing from both his father and Frederick Hopkins, Haldane began to accept the idea that biological systems could be explained in purely mechanistic terms. He even believed that some aspects of life could be imitated or replicated by artificial means, whether chemical or mechanical. His first published account of a future of synthetic food appeared in his 1923 essay *Daedalus*, which predicted the synthesis of sugar and proteins from raw materials like coal and nitrogen. In other publications he would expand this prediction to include fats and oils from minerals and the extraction of sugar from wood pulp and straw. Haldane recognised the technical obstacles to the development of a synthetic diet, notably the appearance of asymmetric organic molecules in laboratory settings. At this point his scientific insight into synthetic food halted. Haldane would instead spend much of the 1930s and 1940s explaining why synthetic food was desirable.[37]

Through numerous lectures, works of popular science, and articles for the *Daily Worker*, Haldane attempted to coax audiences into a future of synthetic food. He deployed several strategies to do so, situating himself against Malthusianism and attempting to remove any sense of a 'natural' versus 'unnatural' divide between farm and factory. The shadow of war gave Haldane both a justification and an incentive to pursue his synthetic food activism. He argued that synthetic food would give national self-sufficiency in case of blockade, spurred on by witnessing hunger first-hand during the Spanish Civil War. After the Second World War, Haldane would turn his attention to capitalism and British imperialism. The scientific priorities of capitalism, argued Haldane, were skewed in favour of profitable luxury goods and weapons. Resources that could have been used to feed the hungry were diverted to produce frivolities and the horrors of the atomic bomb. He would also contrast his plans for a future based on synthetic food with the disastrous East Africa groundnut scheme, arguing that control of food production should be placed in the hands of biologists.

In 1957, Haldane immigrated to India, alluding to the Suez crisis and leaving newspapers with the impression that his move was to protest imperialist massacres in Egypt (Clark, 1968: 203). In fact, one reading of Haldane's pre-planned migration suggests

that he left Europe due, in part, to the focus of geneticists on natural selection and the survival of the fittest. Haldane wished to 'escape from the dominant paradigm of evolutionism' and instead focus on population genetics (Zimmermann, 1996: 301). His scepticism that natural selection always acted as a tool for honing the fitness of individual organisms dated back to at the least the 1930s, helping to explain some of his disdain towards Malthusians, who reached for eugenic solutions to a growing global population (ibid.: 284). Food technology offered Haldane one way of challenging Malthusian beliefs. The embrace of Malthus and eugenics in the West, Haldane indicated, was a further indictment of the poor state of science in those societies. In his critique of the 1944 Royal Commission on Population, Haldane mused that a 'professional scientist' would have been able to point out facts about population growth and decline that 'would have made the Commissioners less respectful to Malthus in their opening sections'.[38]

By reconstructing Haldane's beliefs regarding synthetic food, we can situate him in a tradition of 20th-century technological optimism that sought to replace the natural with the artificial in the life sciences, or at least to present a simplified biochemical approach to diet and nutrition (Landecker, 2016: 158). We can also recognise that synthetic food served larger purposes for Haldane, allowing him to point to a perceived disfunction in the relationship between science and society. In a 1938 essay, he complained that science was not democratically organised. 'If science is to be advanced in this country as it should', he wrote, 'we need more democracy in the laboratories, and also more democratic control of expenditure on research'. This change would occur only if 'the people' were educated about science, instead of being kept ignorant of its workings. 'For a knowledge of science leads to a realization of the huge amount of knowledge which could be applied to the public benefit if industry, agriculture and transport were organized for use and not for profit', he argued. 'And knowledge of this kind is dangerous to capitalism.'[39] In other words, the priorities and funding of science were inadequate under existing social and economic conditions. A widely acknowledged factor in Haldane's turn to Marxism and his admiration of the Soviet Union was his desire to raise the status of science and scientists in society (Dronamraju, 2017; Filner, 1977; Subramanian, 2020). Synthetic food was co-opted by Haldane to serve this larger cause. It made for the perfect example of how a beneficial technology could be developed only if control of science was turned back over to scientists.

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Notes

1. Article on population, n.d. (mid 20th century), UCL Digital Collections (https://www.ucl.ac.uk/library/digital-collections), JBS Haldane Papers (hereafter 'Haldane Papers'), Haldane Box 9, HALDANE/2/1/3/34, ff. 12–13.
2. 'Why I Am Cooperator', 1942, Haldane Papers, Haldane Box 4, HALDANE/1/2/63, f. 48. In this unpublished autobiography, Haldane described *Daedalus* (1923) as a hasty rewrite of an essay he had originally written in 1914.
3. 'What Blockade Means', 1939, Haldane Papers, Haldane Box 10, HALDANE/2/1/3/28, f. 3.
4. 'Why I Am Cooperator', f. 90.
5. 'Why I Am Cooperator', f. 62.
6. 'Why I Am Cooperator', f. 63.
7. One important event at the John Innes was Haldane's encounter with his colleague and future rival Cyril Darlington (Harman, 2004).
8. Essay on food production methods, n.d. (mid 20th century), Haldane Papers, Haldane Box 4a, HALDANE/1/2/100, f. 3. On contemporary efforts to make synthetic food palatable to consumers, see Wurgaft (2020).
9. Lecture at Columbia University, 1935–40, Haldane Papers, Haldane Box 6, HALDANE/1/3/3, f. 17.
10. Lecture at Columbia University, f. 4.
11. Lecture at Columbia University, f. 9.
12. Lecture at Columbia University, f. 14.
13. Lecture at Columbia University, f. 4.
14. Essay on food production methods, f. 2.
15. 'Why I Am Cooperator', f. 73.
16. 'Plants and Animals in Human History', 1936, Haldane Papers, Haldane Box 5, HALDANE/1/2/172, f. 1.
17. Essay on food production methods, f. 5.
18. Essay on food production methods, f. 3.
19. 'Why I Am Cooperator', f. 1.
20. British Cattle Breeders' Club, April 1948–January 1949, Haldane Papers, Haldane Box 36, HALDANE/4/26/8, f. 4.
21. Letter from Haldane to Lovatt Evans, 11 December 1946, Haldane Papers, Haldane Box 12, HALDANE/3/1/3/3.
22. Essay on food production methods, f. 1.
23. 'Why I Am Cooperator', f. 89.
24. 'Why I Am Cooperator', f. 83.
25. 'Marxism and Prehistory', n.d. (1940s), Haldane Papers, Haldane Box 7, HALDANE/2/1/2/55, ff. 1–2.
26. Essay on food production methods, f. 3.
27. 'Why I Am Cooperator', f. 73.
28. 'Why I Am Cooperator', f. 10.

29. Letters between C. F. C. Hawkes and Haldane, April 1942, Haldane Papers, Haldane Box 28, HALDANE/4/15/16, f. 2.
30. Letters between Hawkes and Haldane, f. 3r.
31. Article on domestication of animals, 1948, Haldane Papers, Haldane Box 9, HALDANE/2/1/2/90, f. 7.
32. 'Synthetic Food', n.d. (mid 20th century), Haldane Papers, Haldane Box 4a, HALDANE/1/2/103, f. 3.
33. 'Synthetic Food', f. 4.
34. 'Synthetic Food', f. 2.
35. 'Synthetic Food', f. 3.
36. 'Why I Am Cooperator', f. 72.
37. 'Why I am Cooperator', f. 83. There is no indication that Marxism influenced Haldane's technical understanding of synthetic food, though he would claim that the paradoxes he encountered during his later work on population genetics would force him to adopt Engels' 'dialectical terminology'.
38. Article on population, f. 13.
39. 'How British Science Is Organised', 1938, Haldane Papers, Haldane Box 10, HALDANE/2/1/3/34, ff. 3r–3v.

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