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It Is All Interconnected – A Brief, Comparative Planetary Limits and Lifestyle Medicine Analysis of Production, Diet and Lifestyle During Three Stages of Human History

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Abstract. This interdisciplinary article examines interconnected issues of human and planetary health related to diet, disease, social organization, agricultural production, resource depletion and environmental damage. Largely egalitarian diets and lifestyles characterized prehistoric hunter-gatherer cultures. The Roman Empire serves as an example of the ultimate direct outcome of the Neolithic Revolution. As with the interconnected Mediterranean World of the Roman Empire in the second-third centuries CE, pandemic disease has likewise struck our third stage, the modern industrialized United States, in two centuries running. Prophylactic medical techniques, however, have brought these outbreaks under control more rapidly. The hyper-abundant products of modern agriculture and the advances of highly technological medical care have extended lifespans of twenty-first century Americans far beyond those characteristic of the two earlier eras. Certain interconnected human and planetary limits, however, appear to have been reached. Recently, US life expectancy has "shockingly declined" to a mere 76.4 years amidst an upsurge in diet-linked chronic diseases.

Keywords: Diet, Lifestyle, Prehistory, Roman Empire, Modern World

1 Introduction and the First Stage, Prehistory: Hunter-gatherers in Nature to the Neolithic Revolution

In the complex and interrelated human and planetary health challenges that confront us in the twenty-first century, there are interrelated types of sins of consumption and prevailing human attitudes underlying them that fuel negative trends regarding human *and* planetary health. A comparative historical examination reveals timeless linkages amongst these phenomena. This interdisciplinary article concentrates on the interconnected human and planetary health results of diets, modes of agricultural production and types of societal organization. The broader prehistoric period, the Roman Empire and the modern United States serve as referenced points of human civilization. Human prehistory began with the earliest hunter-gatherers—*hominids* in Africa around 2 million years ago. Archaeological digs in modern-day Israel have revealed hunter-gatherer societies from 800,000 years ago that possessed an "intricate knowledge of

plant life." The diet of these hunter-gatherer communities consisted of fifty-five different types of naturally occurring plants supplemented by fish [1]. From 200,000 BCE to 10,000 BCE, with the appearance of *Homo Sapiens* (modern humans), prehistoric cultures grew more complex. The development of new tools and weapons allowed for the hunting of larger animals. Differentiation of gender roles also became more pronounced. Nevertheless, highly egalitarian social structures remained (and remain) the norm both in prehistoric hunter-gatherer cultures and those that continued to exist after most humans made the transition to living in agricultural communities during the Neolithic Revolution, beginning 12,000 to 10,000 years ago [2]. Direct study of surviving hunter-gatherer communities and scientific evidence gleaned from the archaeological remnants of past ones, including from the emerging science of archaeo-parasitology, shows a very consistent pattern in this respect. Similarly, these societies lived as part, unlike the post-Neolithic Revolution communities that came later, of the natural world and did not destructively alter its balance. Active and healthy lifestyles were also mandatory amongst all members of such communities–whether engaged in hunting or foraging [3].

It is, however, important to note the words of the seventeenth-century English philosopher Thomas Hobbes, "Life, in the state of nature, is solitary, poor, nasty, brutish, and *short*" [4]. One should not over-romanticize the lifestyles of hunter-gatherer societies. Their members were grimly vulnerable to starvation, malnutrition, deadly or debilitating injury, parasites, disease (though low population densities would have been an epidemiologically mitigating factor) and the elements. Nonetheless, from the vantage point of a modern society that is immeasurably more technologically and organizationally complex but no longer part of the natural planetary balance and characterized by rampant chronic disease, depletion, climate destabilization and extreme inequality, some aspects of hunter-gatherer cultures seem admirable. The Neolithic Revolution, by contrast, was the foundation of every change that followed. This is a point made eloquently in Daniel Quinn's award-winning 1992 novel *Ishmael*:

> The work begun by those neolithic farmers in the Near East has been carried forward by one generation to the next without a single break, right into the present moment. It is the foundation of your [humanity's] vast civilization today in the same way that it was the foundation of the very first farming village [5].

Bands of human hunter-gatherers had spread to nearly all parts of the habitable world by 11,000 BCE. Localized exhaustion of prey and plant species in certain warmer more habitable areas of the globe, combined with more frequent clashes with other hunter-gatherer bands, resulted as the earlier strategy of relocating became less effective. Both trends were the products of higher human population densities—though these were still extremely low by modern standards. In turn, "forced" interest in such less desirable natural food sources as wild wheat and barley helped reinforce another emerging trend [3]. The forward elements of the Neolithic Revolution, the transition to settled pastoralism and animal domestication originated around 12,500 BCE in Mesopotamia. Yet, the Neolithic Revolution also was not rapid, universal, or particularly desirable for many. The new grain-based diet proved less healthy overall, and the archaeological record indicates that the average size of human beings *de-*

creased as a result. Agriculture was hard and time-intensive work. Along with shrinking physically, post-Neolithic Revolution humans enjoyed less leisure time. Human societies also became more socially stratified. By around 3000 BCE, however, the Neolithic Revolution and the social, dietary, productive and lifestyle trends associated with it had largely triumphed. Over further millennia, the pastoral societies birthed by the Neolithic Revolution were transformed [1].

2 The Second Stage: Pre-industrial Agriculturally based Societies, the Example of the Mediterranean World of the Roman Empire

Despite being ancient, the Roman Empire was one of history's most organizationally sophisticated and geographically extensive pre-industrial, agriculturally based societies. Rome is an excellent example of that stage of human civilization. The egalitarian social and dietary patterns of hunter-gatherer societies were a distant memory as the Roman Empire reached its height in the first and second centuries CE. However, most Romans (the poor) still ate a simple plant and grain-based diet that by modern standards was surprisingly healthful (despite the reliance of the urban poor on quick snack counters). These, still preserved and visible today in Pompeii and Herculaneum, were ancient Rome's equivalent of fast food. The poor would also sometimes consume pork or other meat in a stew. A typical urban Roman "workman's lunch" might have consisted of cabbage, garlic, herbs, rosemary, sage, corn, pulses, cheese, salt, lovitch, rue, bread, honey, and olive oil mixed together in a porridge. All of this would have been washed down with plentiful (likely boiled) water from the aqueduct system or a watered-down sweetish wine called mulsum [6]. Though famine in the Roman Empire was uncommon and the empire seems to have regularly generated surplus food (particularly grain), there is evidence that the poor were sporadically prone to caloric deficits and/or malnutrition due to dietary insufficiency. This despite the state institution of the grain dole and, at times during the imperial period, a pork dole made possible by "intense" pig cultivation [7], [8].

With Greco-Roman medical humourism lacking germ theory, wealthy and poor Romans alike were also highly vulnerable to infectious disease. The densely packed cities (with higher population densities than modern urban centers) of the empire were fed and supplied by far-reaching, particularly maritime (with grain supertankers crisscrossing the Mediterranean) but also overland distribution networks. Imported pathogens also invisibly superseded their natural biogeographical niches by following these trade routes; repetitive annual seasonal patterns of mortality from ecologically localized infectious diseases also prevailed. The enhanced epidemiological burden of infectious disease stunted growth and shortened human lifespans [9]. There were also devastating novel pandemics such as the second century CE Antonine Plague (likely smallpox) and third century CE Plague of Cyprian (likely a viral hemorrhagic fever with a Marburg evolutionary lineage filovirus a candidate pathogen) to which the empire's geographical expanse, extended trading networks (spanning biogeographical spheres) and urbanization made Romans vulnerable [7]. Food and waterborne parasite infections were also common, though the vast majority of these do not seem to have

risen to a level capable of producing serious health effects up to and including mortality. Greco-Roman physicians, omnipresent in urban and military settings, effectively treated these infestations with cardamom and myrrh—a remedy still used today [10].

Wealthy Romans consumed a greater volume and wider variety of food (meat, pastries, rice, etc.) than did the poor. The diet of Rome's rich was, by modern lifestyle medicine standards, much *less* healthy than that of the poor—though its basic caloric/nutritional sufficiency was not an issue (as seems to have sometimes *been the case* for the lower classes). These varied foods were seasoned with spices imported from well beyond the imperial borders, particularly through a maritime monsoon-wind aided trade with India conducted through Roman Egypt's Red Sea ports. Lavish multi-course banquets, featuring binge-eating, were a symbol and reward of wealth and status in Roman society [11]. These dietary practices, as well as a potentially sedentary aristocratic lifestyle (daily tasks were performed by slaves) probably led to results medically documented during the modern era—higher rates of obesity and chronic disease. Though exercise, widely engaged in by upper-class Romans, would have somewhat mitigated against these negative trends. The poor and slaves would have led more occupationally active lifestyles but were also at far greater risk of debilitating work-related injuries from repetitive manual labor and/or malnutrition. There are some cautions that apply: Dr. Kyle Harper, for instance, makes the observation that 'there was no such thing as a 'Roman diet'—only the aggregation of locally and regionally variable diets…" Or to put it another way, given class differences and the imperial Mediterranean world's interconnectivity in terms of food supply (but also its agricultural and culinary diversity), the Roman Empire was characterized by regional diets with shared features [9], [12]. Similarly, the problems inherent in the notion of a Roman "middle class" are analytically complex. Rome's large military establishment, however, seems to have often constituted both a vehicle for social mobility and a type of [albeit exclusively male] middle class. This was particularly the case in the Late Republican and Imperial periods of Roman history, as the military became more professionalized. Both surviving historical documentation, generated by this "greatest bureaucracy of antiquity,"and the more recent scientific work of modern archaeo-parasitologists have produced a detailed picture of what Roman legionnaires ate. Roman forts had effective sanitation and freshwater supplies. In part to reduce defense budgets, the legionary diet was largely plant-based. In the first century, each of Emperor Augustus' 300,000 soldiers consumed, on average, one-third of a ton of corn per annum. Portions were large, but (like modern athletes) legionnaires trained, marched and exercised ceaselessly. Vegetables, fish, fruit and bread seem to have been the core of the military diet. Meat was consumed as well (with quantity and type varying with the circumstances of a given posting). Legionnaires seem to have only rarely suffered from malnutrition or poor-quality food [13].

Archaeo-parasitologists have documented the diets of individual Roman soldiers to such an extent that we can clinically evaluate them! One first-century CE centurion serving at Alphen aan der Rijn in the modern-day Netherlands ate, amongst other items, a variety of vegetables, fish, mussels, beans, grains, nuts, as well as fruit (apples, pears, grapes, peaches, etc.). The food he consumed was both locally produced and imported from around the empire. His legionary granary had, however, become

infested with grain weevils; the centurion also hosted whipworms. Neither parasite was present at levels that would have posed any significant threat to his health [14]. Given their active lifestyle regimen of training and physical fitness as well as their sufficient and generally healthy dietary habits, it is unsurprising, from a modern lifestyle medicine perspective, that legionnaires like the Alphen Centurion lived five years, on average, *longer* than Roman civilians *despite* the considerable dangers inherent in ancient military life [13]. In general, modern estimates of overall Roman life expectancy vary between 25 and 30 years. All sources agree that such averages were dramatically skewed downward by colossally high rates of infant and childhood mortality, due primarily to infectious diseases that Greco-Roman physicians could neither understand nor cure. Average life expectancy doubled between the ages of 0 and 5. A man or woman of any social class (and the majority of these would have been the poor and NOT the upper classes) surviving into maturity might well live into their fifties or early sixties [15].

Roman agriculture constituted an intensification, extensification and organizational-productive leap from earlier agricultural standards fueled by, amongst other innovative technologies, water provided by Rome's impressive system of aqueducts. Roman engineering feats, such as construction of harbors, clearance of forests, draining of marshes, building canals, etc. were often linked directly to attempts to extensively increase food production or ensure more efficient distribution– particularly to the empire's key urban nodes. But the nearly million-strong city of Rome's (...it was incarnated as the goddess *Annona*) historical outlier of a food supply and distribution system was powered largely by sheer extensive scale, increased regional specialization made possible by efficient and scalable means of maritime and overland transport and massive use of cheap slave labor [16]. The system was not modern or technological in terms of consistent patterns of improving efficiency and progressive intensification of method; it did not greatly evolve technologically or organizationally. Roman agriculture and food distribution networks would have produced instances of environmental damage as well as direct and indirect epidemiological feedbacks (malaria-causing plasmodium parasites, for instance, invaded low-lying wetland areas drained for agricultural purposes), and the pandemic-causing pathogens underlying the Plague of Cyprian (possibly also the Antonine Plague) probably entered the Roman Empire through Red Sea ports such as Myos Hormos and Berenice [7], [12]. Agricultural production also resulted in environmentally-degrading local monoculture; the overall extent of environmental damage from the Roman agricultural system is, however, unclear. The theory that the agricultural lands of the Western Roman Empire became depleted through overuse is much broached but far from proven [16]. Patterns of Mediterraneanization that paralleled the effects of modern globalization (the Roman Empire included vast intercontinental territories that spanned Europe, Africa and the Middle East) through resulting economies of scale produced localized depopulation of small farms and rural communities; these, albeit anthropogenically-altered, lands were reabsorbed by nature. Significant climate change also occurred during the Roman era, particularly with the fading of the so-called Roman Climate Optimum from the late second century onward, but the causes (such as volcanic eruptions, cycles of solar forcing, ENSO events, etc.) were natural as opposed to anthropogenic [9]. The West-

ern Roman Empire's collapse led to significant changes in human diets (becoming subsistence level, less diverse and more localized) as the complex and interconnected production and distribution networks of the empire frayed and disappeared. Without them, maintenance of an urban lifestyle became far less sustainable; the population of the city of Rome shrunk by over 90% [7].

3 The Third Stage–Industrialized Societies: The Modern Globalized United States

The hyper-abundance of industrialized agriculture and the advances of highly technological medical care have extended the lifespans of twenty-first century Americans far beyond what would have been possible during the prehistoric or Roman eras. However, the seemingly limitless supply of food and the efforts of modern medicine have reached a point of diminishing returns. Recent predictions of average American life spans exceeding one hundred years have been wildly over-optimistic. American adults are increasingly sedentary—spending copious time on computers, phones, watching television, consuming mass entertainment, etc.,—while spending little time on physical exercise. In early 2020, the CDC found rates of "not participating [at all] in any leisure-time physical activities in the preceding month– activities such as running, walking, exercise or gardening, per individual US states, between 17.3 to 47.7% [17]. Overall, US life expectancy stood stalled (pre-Covid-19 pandemic) at just under 79 years in 2019 [18]. Over the prior four years (2015-2018), however, American life expectancy slightly declined. By 2023, in the wake of the Covid pandemic, US life expectancy had "shockingly declined" to a mere 76.4 years [19]. Despite food production abundance, hunger and malnutrition have not been eliminated. In 2010, following the Great Recession, approximately 16% of the US population was, at least sporadically, "hungry or food insecure" [20]. For most Americans, however, the main limiting factor for longevity seems to be diet– not in terms of caloric quantity but rather nutritional quality. A recent study by the American Heart Association showed that only about 1% of Americans had a healthy eating score in four out of five basic categories [21]. In addition to dietary choice, ubiquitous modern food additives are linked, with varying levels of causal certainty, to a wide spectrum of deleterious health effects. The common preservative titanium dioxide, for instance, has been labeled as carcinogenic and linked by researchers at the National Institute for Occupational Safety and Health to a range of chronic respiratory ailments [22]. A variety of food dyes (still commonly used in the United States) were banned, in 2013, by the European Union over linkages to cancer *and* ADHD in children [23]. One single food additive, high fructose corn syrup, is linked to toxic mercury exposure, hypertension, long-term liver damage, increased risk of type-2 diabetes and weight gain– bolstering the (increasingly globalized and no longer particularly American) modern "plague" of obesity. Yet, high fructose corn syrup remains one of our most common modern sweeteners [24]. Additionally, with 2020 US urbanization levels, for example, at 83% and growing (with the virtual reality of technology an enhancing factor), Americans live nearly completely divorced from the natural world [25].

As with the Roman Empire in the second and third centuries CE, pandemics (Spanish Flu's H1N1 virus and Covid-19) have struck the globally connected world in two successive centuries. Prophylactic medicine (including vaccines) has, however, brought these outbreaks under control far more rapidly. Covid's pathology, however, destructively feedbacked with the underlying pathologies of modern chronic disease in ways that ancient pandemics did not with underlying seasonal patterns of infectious disease [26]. As the medical writer Dr. Michael Greger commented, we have recently [if not fully] left the Age of Pestilence and Famine and entered the Age of Degenerative and Man-Made Diseases. In his 2015 work *How Not to Die,* Greger notes, "In 1900 in the United States, the top-three killers were infectious diseases: pneumonia, tuberculosis and diarrheal disease. Now, [the killers] are chronic diseases rooted in diet and lifestyle: heart disease, cancer and lung disease" [21]. Chronic diseases are strongly linked with modern dietary patterns. Non-celiac gluten sensitivity (NCGS) is a separate ailment, for instance, from both celiac disease and wheat allergies. A combination of a weakened intestinal barrier and an immune response in sufferers causes a range of stomach issues, diarrhea, fatigue, headache and anxiety. The commonplace symptoms caused suspicion that the problems were psychosomatic, but medical research has clinically-confirmed the ailment. Up to 6% of America's population may suffer from varying degrees of it. NCGS has been (less than definitively) linked to the chemical compound glyphosate—an ingredient of the ubiquitous weed killer *Roundup* [27]. The broader effects of the world's move toward a high fat, high sugar, animal-sourced, highly processed diet, based upon the abundant output of modern industrialized agriculture and laden with preservatives and other artificial additives to enable fully globalized, as opposed to merely Mediterraneanized, networks of distribution have been seen more fully in the United States—as the shift away from healthier, mostly plant-based traditions, occurred earlier. But evidence of negative effects on human health is buttressed by the experiences of societies that have undergone similar changes more recently, such as China. The spread of incrementally debilitating chronic diseases like obesity and diabetes are inextricably linked to this dietary shift [21]. A fuller picture of this new Age of Degenerative and Man-Made Diseases emerges from the following chart.

Current Mortality in the United States

	Cause	**Annual Deaths**
1.	Coronary Heart Disease	375,000
2.	Lung Diseases (Lung Cancer, COPD, etc.)	296,000
3.	Iatrogenic Causes*	225,000
4.	Brain Diseases (stroke, Alzheimer's, etc.)	214,000
5.	Digestive cancers	106,000
6.	Infections	95,000
7.	Diabetes	76,000
8.	High Blood Pressure	65,000
9.	Liver Disease (cirrhosis and cancer)	60,000
10.	Blood Cancers	56,000

**Death by Doctor Greger [21]*

Rather than the egalitarian trends of prehistoric times, the modern United States replicates the Roman pattern of dichotomies in the diets of differing social classes, though with both striking similarities and differences. In 2008, researchers Nicole Darmon and Adam Drewnowski studied class-related dietary trends across a wide spectrum of industrialized societies including the United States. Based on their study of empirical data and using "computer modeling of dietary habits subjected to cost and other constraints," Darmon and Drewnowski concluded that "morbidity [... a link was also found to osteoporosis] and mortality" rates followed a "socio-economic gradient." "Lower quality diets tended to be consumed by groups of lower SES [socio-economic status] and more limited economic means." The affluent consumed fewer sugars and unhealthy fats. They also ate more fresh fruit and vegetables. The less well-off ate "energy-dense diets that are nutrient poor." The rich consumed more whole grains as opposed to less-healthy refined cereals eaten by the poor [28]. Exactly as with inequality in Roman times, there is evidence that such class-based dietary differences, such as fruit and vegetable consumption rates, have increased and are continuing to increase over time. In the twenty-first-century United States and other advanced industrialized societies, the affluent are "healthier and thinner." Unlike in ancient Rome, there is no "surprising or hidden" dietary benefit for the poor in the twenty-first century United States. With a population that surpassed 334 million in 2023 (approximately 4.5x the population of the Roman Empire at its height in 165 CE), the sheer amount of food consumed in the United States is monumental [29], [9]. In terms of direct harvesting/depletion from nature, the impact is most directly felt in terms of fishing. A heralded new era of "rebuilding and recovery" might indeed be a statistical (fleeting) feedback from the Covid pandemic. Despite landing only 8.4 billion lbs. in 2020 (a 10% decline from 2019) valued at $4.8 billion, US fisheries holistically were still 20% overfished, according to a report from the National Oceanic and Atmospheric Administration [30].

Global production of food is at record levels. Productivity increases have, however, been declining over the last decade or so. While scientific and technological advances in environmental-damage mitigation have been considerable, the sheer scale and intensity of modern agriculture and the complex countervailing economic realities involved make it difficult for food production systems, as currently structured, to avoid a variety of environmentally deleterious effects. These include nitrogen and pesticide runoff, destruction of biodiversity, greenhouse gas (GHG) emissions (carbon dioxide, methane, nitrous oxide, etc.) and water contamination– as via spread of such pathogenic bacteria as *Giardia* and *Cryptosporidium* [31]. Depletion of water resources, for example the Ogallala (High Plains) Aquifer, and of topsoil resources (through erosion or overuse) are also recurring problems. According to a 2015 National Library of Medicine/National Center for Biotechnology Information report, "The pathways by which a food system leads to [harmful] environmental effects display characteristics of complex systems' with many deleterious "indirect effects" that are not always immediate or easy to discern: feedbacking destructive algal blooms indirectly linked with nitrogen runoff (such as the devastating one that afflicted Lake Erie in 2011), herbicide resistance in weeds, unintended pollinator destruction due to pesticide use or the locally-environmentally-damaging impacts of confined animal feeding opera-

tions, even when GHG issues are mitigated through use of composters or anaerobic digesters [32].

4 Conclusion: Interdisciplinary Lessons from History

The unifying idea embodied throughout this article is that, at whatever stage of civilization (prehistoric, ancient or modern), human health and planetary health are provably, crucially and inextricably linked through an ever evolving but enduring and interconnected complex system/dynamic. This nexus is centered, in a highly transdisciplinary manner, around planetary limits, the holistic direct and indirect effects of environmental disruption as well as complex human diet, lifestyle, health and agricultural production trends. Comprehending the workings of these ever broadening, deepening and intensifying relationships is an often-baffling task. Yet, the potentially catastrophic consequences, for both humanity and the planet, of the negative effects associated with the functioning of that intricately interconnected web are ever clearer around us.

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