

## Meat and Vitamin B3

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DOI:

[10.5772/intechopen.100056](https://doi.org/10.5772/intechopen.100056)

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*Document Version*

Publisher's PDF, also known as Version of record

*Citation for published version (Harvard):*

Williams, AC & Hill, LJ 2022, Meat and Vitamin B3: Getting a Grip on Engel's Curve. in JG LeBlanc (ed.), *B-Complex Vitamins - Sources, Intakes and Novel Applications*. IntechOpen, pp. 47-78.  
<https://doi.org/10.5772/intechopen.100056>

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# Meat and Vitamin B3: Getting a Grip on Engel's Curve

*Adrian C. Williams and Lisa J. Hill*

## Abstract

We evolved from herbivores to a meat eating “commons” in hunter-gatherer days and then to a non-egalitarian meat power struggle between classes and countries. Egalitarian-ism, trans-egalitarianism and extremes of inequality and hierarchy revolve around the fair-unfair distribution of meat surpluses and ownership of the means of meat production. Poor people on poor diets with too few micronutrients may explain many inequalities of human capital, height and health and divergent development of individuals and nations. Learning from past successes and collapses from switching trophic levels the lesson is that meat moderation toward the top of Engel's curves, not calorie-centrism, is the best recipe for countries and classes. Improved health with longer lives and higher crystallised intelligence comes with an ample supply of micro-nutrients from animal products namely iron, zinc, vitamin A, vitamin B12 and other methyl-donors (such as choline), and nicotinamide (vitamin B3). We concentrate on nicotinamide whose deficits cause the degenerative condition pellagra that manifests as poor emotional and degenerative cognitive states with stunted lives and complex antisocial and dysbiotic effects caused by and causing poverty.

**Keywords:** Nicotinamide, Vitamin B3, Engel's curve, Poverty, Ageing, Neurodegeneration, Dementia, Cancer, ACE2, Covid-19, Free Energy, Energy gradients

## 1. Introduction

Seeing world history from a meat perspective was initiated by Hinman and Harris (1939) [1] who believed (as did Homer's heroes and many Gods) meat eating was key to the success and power relationships of nations and to class ascension (as if on the “Great Gatsby Curve”). Later Cokburn (1996) largely concurred as had McCay earlier (1912) [2]. De Castro in his “Geopolitics of Hunger” (1952) [3] was concerned over country and postcode food injustice and argued that Malthus (and Ehrlich 1971), was wrong and cereal dependence with increased fertility was the cause, not the effect, of population booms quoting Doubleday's “True Law of Population” (1842) [4] and significant epidemiological evidence that meat eating reduced fertility. Godwin and Boserup also disagreed with Malthus as they felt population pressure was “the mother of invention” and new agricultural technology as has been true, so far, but has not led to a good diet for the poor (“Golden rice” with extra vitamin A being an exception) and the returns may be diminishing or counter-productive (such as by encouraging population booms) and busts from the neolithic on.

McCarrison (1921) [5] and Boyd-Orr (1936) [6] after observations on differential tribal characteristics (such as the pastoralist Maasai being taller and healthier than

cultivators), on different diets in colonial India and Africa, complemented by the discovery of Beri-Beri and Pellagra in the 1940's [7, 8], campaigned for square meals for all. Despite these early initiatives following the science and an analysis of natural experiments, poor nutrition is still the leading cause of death under the age of five as well as causing physical and cognitive stunting and both wasting and obesity. Acute hunger affects 150 million and given little monitoring or screening figures for micronutrient deficiency are likely to be higher than currently recognised, at 2 billion. Geography is critical: if born un-lucky in the lowest 10% of income countries your typical income per head is \$3 a day, making meat unaffordable, compared with \$3000 plus in the richest countries. Country is now as important as class and that was not as true a century ago [9]. Meat may be the real “stuff” of comparative inequality that could be sorted as a practical non-transcendental move dealing with blighted lives, even if it just a start on fairer initial conditions [10–16]. This is not before time (today even in wealthy Europe 10 cm differences in height exist between the Netherlands and the UK), as even back in 1904 it was realised that poverty and poor diet meant the “tenement” child was stunted and had everlastingly poor odds that meant running the race of life with handicaps [17, 18]. Thomas [17] and Hunter [18] suggested poverty should be seen in clinical, not moral terms, relating to loss of income (including from industrial accidents or illness). Here we use pellagra, an archetypal disease of dietary poverty from a (cotton) market failure, as our generalisable example of such a negative externality easily corrected by social insurance or cash given that Engel's curve predicts that more would get spent on meat [19–22].

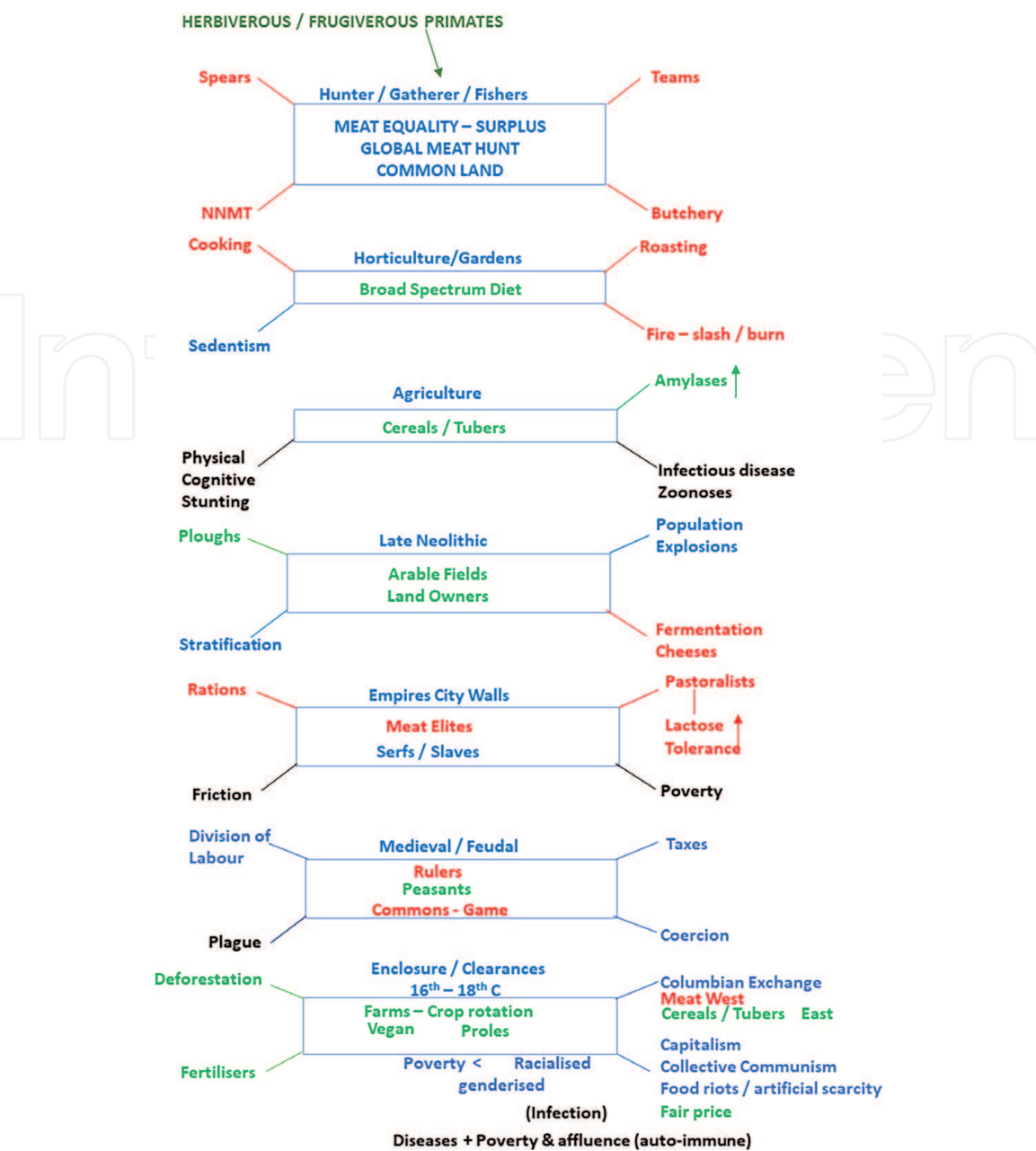
Pro-meat views are not exactly the “zeitgeist” of our times as meat is considered to be a major threat to both health and climate but calls to tax it, for instance, could be a serious misstep so an unbiased unpolarised debate is needed [23]. The human right to basic food “entitlements” that enable capabilities, capacities and optimal human capital may need adequate meat and explain the striking benefits of basic income trials [24–28].

## **2. The demand for meat: predictive pro-active brains**

That the demand for meat is high, but elastic, is not surprising as we evolved as an (A (meat) + 2B (vegetable and fruit)), omnivore as have our cuisines and fusion foods. Our closest living relative's (chimpanzees), eat and fish for insects but hunt meat rarely and not fairly. Fairs fare was our social leap in a software with a “Killer App” where needs based and conspicuous sharing of meat obtained as an “affordance” was the social norm (**Figure 1**). More meat in diet, as with the convergent evolution of the Neanderthals, led to bigger brains with nicotinamide as a key ingredient. Meat intake varied by latitude but once obtained there was a sharing culture with shunning of transgressors by the reproductive in-group - even if seeking meat was the usual cause of inter-band warfare and of global diasporas following animal trails [29–31]. Hunter-gatherers had less “stuff” and what they had was often redistributed in feasts and “potlatches”: they have been considered an affluent society with leisure and family time for cooperative breeding and teaching [32, 33].

## **3. Engel's curves: Families, Countries and Classes**

The need and umami taste for meat is reflected in Engel's law that he based on family budgets in Belgium (confirmed repeatedly) (**Figure 2**) [34–36]. Modified by Bennett [37], this law states that as families become richer they spend less on starchy food but more on meat. Later attempts to define a poverty food line, where a

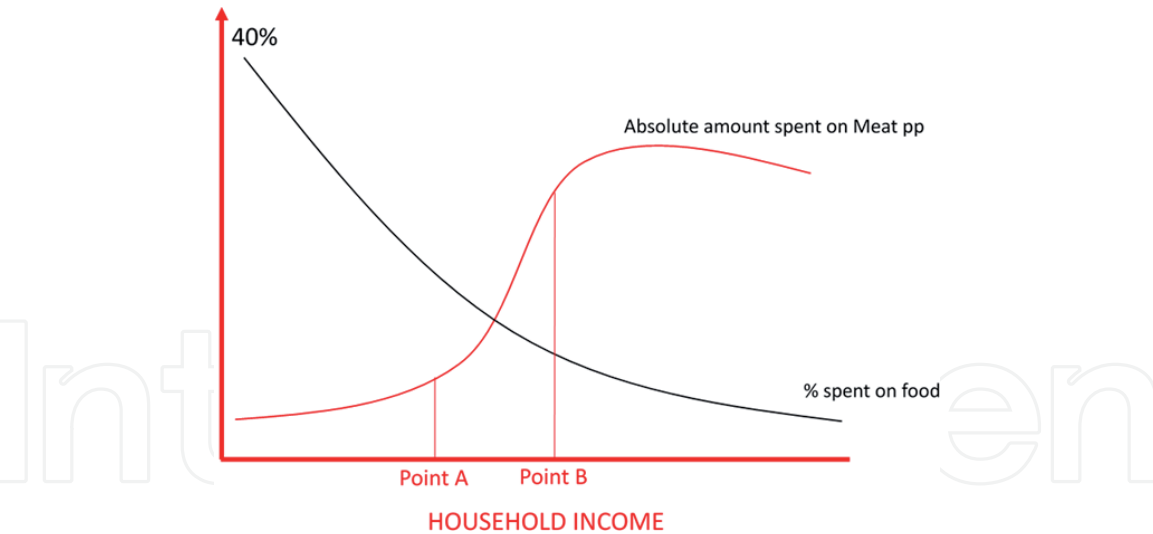


**Figure 1.**  
*A synopsis of our journey from herbivores to omnivores on a high meat diet and socially compulsory meat sharing to extreme meat inequality. Moderate meat inequality may allow for phenotypic variation in the population with cognitive elites and workers with higher fertility at a cost. Severe meat inequality being the basis of much inequality of opportunity and the diseases of poverty (and affluence) as well as much discrimination and dehumanisation of the poor. Fighting for a fair meat ration has caused much friction and migration in the past and could continue or worsen if corrective action is not taken.*

safety net could lie, started with Seebohm Rowntree (1937) [38] and moved on with minimal wages and subsistence rates now \$1.9 per day, although this is widely criticised and is not enough to afford any animal products [39, 40]. The nutritional and biochemical advantages of affording meat, other than being a source of calories, revolve around micronutrients not easily obtained from plants such as iron, zinc, Vitamin A and several B vitamins [41–44]. B12 and Choline are important as methyl donors and B3 to the mitochondrial energy supply and as precursor to metabolic nicotinamide-adenine dinucleotide (NAD) - consumer master molecules. NAD is key to brain growth and “human capital” so meat cannot be trivialised as conspicuous consumption as a “Veblen good” (with exceptions), or part of sexual politics (also with exceptions), and our “demonic” past [45] as it is a vital victual.

We may be more like eugenic eusocial insects with diet-induced castes than we like to think [46–48]. In some societies (such as the Taureg), this is explicit with pastoralist





**Figure 2.**  
*Engel's law. As incomes rise the proportion spent on food (and rent) falls giving a disposable income for "luxury goods" and education and then services and is the consumer base for modern economies. As incomes rise the absolute spend on meat rises and on starches falls improving human capital and "grey matter" as micronutrient needs are met. There may be increased temptation, compared to the past, to deviate from this law when cheap calories and processed foods, costing 1/5th of vegetable equivalents, are available let alone other commercially available distractions and fashions.*

nobles eating the crops of their cultivating slaves [49]. Poor maternal and infant diet may mean that those in poverty are born unequal, making and unmaking minorities, particularly if that is then exacerbated by NAD consuming chemical pollution or excess infections. This is a preferable view point that sets limits that are easily corrected, than the idea of genetically determined human sub-species as first suggested by Linnaeus (1758) [50] and modified by Blumenbach (1795) [51]. Eugenicists and social Darwinists agreed but these views were refuted early by Buffon, Darwin himself and Boas. Boas noted that exposure to new diets changed immigrant people's "fleeting and superficial" differences just as the "Melting Pot" suggested and that hybrids (despite anti-miscegenation laws) were fertile and healthy arguing against separate species - first investigated on Pitcairn Island after the mutiny of the Bounty [52, 53]. Satisfying this need for better diet and meat in new power battles, whose old motives and underhand mechanisms we discuss [54], is important before society can progress and modernise linking meat, disease and demographic transitions, that remain patchy [52–56]. As Darwin noted on his Voyage of the Beagle *"if the misery of our poor be caused not by the laws of nature, but by our institutions, great is our sin"*.

#### 4. Supply of meat

Let us first review the supply-side by rough ages of globalisation from pre-history hunting parties to "factory farm" industrialisation in the context of our NAD supply whilst harnessing external sources of energy (originating in NAD dependent photosynthesis) in metabolic network involving the major carbon, hydrogen, phosphorus and nitrogen cycles of life, that we have exploited and disrupted [26, 55–59].

#### 5. Planet of the apes to *Homo sapiens*: Meat cornucopia

The "cradle of mankind" was in the African Rift valley after climate change led to deforestation expanding the savannah grasslands and supporting a population

explosion of herbivores. Hominids evolved into this ecological niche and formed prosocial hunting parties aided by new technology from spears to the bow and (poison) arrow and dog domestication. *H. sapiens* emerged with egalitarian “reverse dominance” structures with “reciprocal altruism” to kin and selected non-kin with meat sharing and an extensive cattle vocabulary and spiritual connection with animals and plants [29, 60, 61]. Human phylogeny and ontogeny (“EcoDevo”) revolved around cooperative feeding and a shared intentionality over resourcing meat, and over breeding with alloparenting, in three-generation families. Long dependent childhoods allow for gene expression intersecting with diet and epigenetic learning (such as hunting and gathering from tribal encyclopedias), allowing easier adaptation to changing environments [62, 63].

Pit roasting or boiling were the cooking (extra-somatic digestion), methods for meat and drying then salting for storage in newly invented pottery in “delayed return” societies [64]. Hunting and trapping and fishing (some forming the “Salmon nations”), parties crossed the globe, including via Beringia, extirpating animal (such as the woolly mammoth) and fish, sea-mammal and bird species - that alongside climate change led to the demise of megafauna and meat shortages temporarily alleviated by concentrating on smaller game. The interest and obsession about meat and cattle is well preserved early in Cave paintings of Aurochs and Mammoths and sculptures (such as the “Lion man” representing hunting prowess) and other clay artefacts suggesting an early religious element with a veneration of cattle before they were even domesticated – when later some became gods and pastoralism was depicted in rock art, wall paintings and figurines [65].

This was the longest successful subsistence economy in our history and was the environment to which we largely adapted. Extra amylases (to digest starches), and lactase persistence and milk, bread and beer fermentation produce are subsequent genetic and cultural co-evolutions. This period was culturally, with the origins of science and music [66] and metabolically affluent with the sort of joined-up thinking that later influenced the physiocrats [67–69]. The advent of cooking and life of yeasts added to this metabolic thread – now lost and needing a new social contract [70–73]. Populations on the ancestral diet remained low, affecting division of labour, so it may be a “Paleofantasy” that these high meat diets were best, as they must have changed for a reason [74].

## **6. The (Neolithic) agricultural revolution and cerealization: grass roots**

Homo evolved as a food producer and processor first with horticulture and play farming then cultivation of grasses (that we cannot digest easily unlike ruminants), and the co-domestication of cereals [75, 76]. Animal domestication and pastoralism came later in trading or conquest driven relationships that usually involved a degree of specialisation with nomads providing the meat [77–79]. Herdsmen and pastoralists come in various forms, starting around 1000 BC with the humpbacked sanga cattle in Ethiopia and reindeer further north, depending on the seasonal transhumance distances between summer and winter pastures that need to be travelled. Despite managing a distributive and exchange system, specialist pastoralists, such as those with horses and wheels, drove meat inequality hard with property ownership (cattle, rather than land), and controlled meat surpluses [80–83]. Seafood was exploited more variably and often as a “famine food” perhaps as the “protein punch” was low and the effort high or over-fishing is too easy. Some in the “fertile crescent” were better off in “lucky latitudes” across temperate zones with mixed farming roping in animal predomesticates than others in the Americas and Africa (who also had carnivores and parasitic microbes to contend with in the tick and “Tsetse belt”).

We can now see various seeds of hierarchy (worse in the hunting season), inequality and how a trans-egalitarianism centred on the meat supply and its ownership

might have developed [84, 85]. Sedentism, materialism and social stratification and pathology emerged with a well fed ruling “cognitive” non-food producing class and a less well-fed worker and slave class as a proletariat with, by definition, high fertility [86–88]. Meat became commodified and Engel’s curve kicked in and got distorted later with the need for money competing over just about everything that used to be a common good or was a new luxury [89]. Where and when meat was scarce captured proles were used as (as was consecrated sacrificials) meat in the Americas as state-registered cannibalism; less-coercive mechanisms of soft-power elsewhere made sure the rich were easily able to afford meat [90]. A (2nd) cerealization and calorieization event around 1000 AD in Europe specifically separated meat-eaters from grain-eaters with social penalties for transgressors in “Bourdieuian” social enclosures. Another transition phase involved tributary-redistribution by the feudal upper classes putting on regular feast days or by monasteries but then our niche construction comestibles were trusted, perhaps unwisely, to the market place [91–93].

## **7. Enclosure movements, clearances and conservation**

Physical enclosures restricted the commons and hunting and pasture rights for serfs [94–97]. The argument used was that productivity is increased by landowners, by crop rotation improving nitrogen fixation and winter feed (turnips) for animals, compared with the overgrazing or overfishing of the “tragedy of the commons” or “prisoner’s dilemma”. Such arguments can be true of socialist strategies or privatisation [98] or cooperation as in “Stag Hunt” games and farmer cooperatives. Serfs were denied access to free meat and poachers fined or paid with capital punishment as in the Black act of 1723. “Rule of Capture”, or gleaning rarely applied. Thomas’ Paine (1796) in his “Agrarian Justice” [99] and the more radical Spence (1829) [100] started a chain of thinking about landowner’s debt to others in society and that “homesteading” (as in “go west young man”), or at least compensation for the removal of pastureland should be available to all [101–103]. By forcing workers to work for an income, now usually allotments in cities, the poor were at the mercy of market forces and the price of meat (factory workers often paying three-fifths of their wages in food).

Expropriation of land resources, as in the Scottish Clearances, also damaged local peasant farmers to the benefit of the meat supply to richer cities, becoming yet another basic mechanism of inequality and discrimination with loss of social and human capital for many – who often emigrated [104–106]. Despite higher incomes and more meat per person for a while after the population decline caused by the Black Death, by the 1700s the poor became virtually vegetarian [107–109].

Conservation efforts later had similar effects, even in the American land of abundance, born amongst worries about non-white population increases destroying habitats to the further disadvantage of the poor with less pasture and hunting rights, driving poaching [110, 111]. The Cape is also a good example, as was India, as white hunters emulating aristocrats largely exterminated big game (after ivory and trophies) with improving rifles up to the High Veld and Limpopo river and set up safari reservations whilst denying locals any right to hunting despite their cattle being devastated by Rinderpest creating pellagra outbreaks - eventually the camera replaced the gun [112].

## **8. The Columbian exchange and aftermath**

This early globalisation event is relevant as the Americas were poorly off for animal domesticates (early hunters had killed off both megafauna and horses).



Low meat diets may have contributed to their easy conquest by the Conquistadors' superior technology and cognitive know-how and by infection, as somewhat immunosuppressed [113]. Here is an example of a low meat culture being "laggards" with their late use of the alphabet, wheels and metallurgy. The Spanish brought horses, sheep, and goats and built ranches on an industrial scale with even feral "plagues of sheep" and a glut of cheap meat: whilst the imports of cereals and tubers contributed to "plague of corn" population explosions in the east [114–116]. Appropriation of Indian lands and the extinguishing of Bison and the rise of cattle/cowboy and "red meat republics" led to a high meat diet for white Americans and a poor meat diet for indigenous peoples [117]. The slave trade also led to a poor low (fatty/flap) meat diet for those forcibly imported from Africa and other indentured peoples.

## 9. Intermission for some early reflections

It cannot be a coincidence that these nutritionally deprived folk were felt to be an "inferior" race although racist, sexist and genetic explanations were invoked even if "Black Spartacus" revolts and humanist ideas gave abolitionists support for the idea we are, indeed, one race. Poor meat, milk and high corn diets were so rife they caused pellagra whose members with poor cognitive and social skills were known as the "Butterfly caste" and considered a degenerate race facing discrimination and the attention of eugenic movements. The eugenicist answer was sterilisation not diet, as discovered by Joseph Goldberger [118]. At times agriculture and maize has been rejected perhaps for this very reason as an "ecology of freedoms" with the ambivalence of "play farming".

This ability to create a man-made economic and dietary environment and then blame the victims or consider them sub-human even in their (spiritual) responses is a fundamental attribution error made easier by physical segregation; even Lombroso, a famous pellagraologist, is best known for proposing (1887) the atavistic "*l'uomo delinquente*" [119–122]. The second amendment did not allow slaves or freedmen to carry arms (except when they ran out of white soldiers), impairing their ability to hunt as did the use of their lands for plantations [123]. Denying such people access to education, health care (believing they have higher pain thresholds or prone to "Cachexia Africana"), or immigration or property rights (losing out on capital gains and heritable wealth increasing their debt) further reinforces stereotyping and ghettos, whilst obscuring the basic dietary cause that is lifelong and transgenerational [124–127].

Perhaps our original social sin is of not sharing, rather than the eating of meat and is the real reason for guilt and blanking over (unfair) access to meat. Displacement to the "narcissism of small differences" with discrimination over surface matters, particularly to people close to us physically or ethnically, is stronger than "clashes of civilisations" or even religions. Such trivia (with no biological basis), may be microaggressive "smoke screens" over competition over neighbouring means of meat production (as in the "curse of Cain" the farmer and founder of nations), and is something we need to overcome with a "species think" more empathetic to strangers on lower rungs (with the added benefit of less loneliness and more diverse friends that also drives ill health [128–133]. Hope comes from the relatively recent history of divide and rule racism (after Bacon's rebellion of 1676 that united poor whites and blacks but then "Jim Crow" laws took over for decades until the success of Civil Rights Movements), suggesting these attitudes are not "hard-wired" in our amygdala and pre-frontal/anterior temporal/posterior cingulate cortical areas (that degenerate in pellagra), and that implicit bias can improve once others are seen as part of a coalition for a common cause, such as survival of the species [134–137].

## **10. Back to colonial times: Space and Race**

It is useful here to differentiate between “settler” colonies, the “plantation” and the “conquered” states. “New Europe’s” such as in Australasia were similar to the Americas in that, at the expense of genocides/holocausts of indigenous populations, they created a meat surplus to export to the European core [138, 139]. Plantation colony peoples (other than the “planters”), suffered from a deterioration in their diet as land and labour were swept up in cash crop farming. Conquered states, such as India, had peasants taxed (providing the European centre with “free lunches”), in a “beggar thy neighbour” policy reducing incomes and impoverishing an already vegetarian diet - with no mercy given in the book-end Bengal famines [140–144]. Repercussions of these policies often born during the cotton empires continue to shape our world with little sight of reparations and restitution to those worst affected [145–148]. For instance, it is well established that dietary intervention during pregnancy improves birth weight and development and academic achievement and blocks the programming of future ailments (including the metabolic syndrome) as first noted in the Dutch “Hunger Winter” of 1944 [149]. So it is important that “battle fatigue” does not set in to this opportunity to correct constructively a past injustice.

More positively imperialism did, like the Columbian Exchange, lead to significant transfers of plants with nutritional or economic - such as rubber) or medicinal value (such as quinine) largely by the Kew garden network instigated by botanists Banks and Hooker) - and animal species, some more productive such as the Hereford and Aberdeen Angus cattle (that largely replaced the shorthorn and Texas longhorn in all but the most arid areas) [150–152].

## **11. 1850s meat transition in Western Europe**

After the 1700s when only the rich ate much meat a meat transition started in Britain (“Rosbifs” as depicted by Hogarth) with its “Hungry Empire” [153]. These times had started with well documented ill health, height and opiate and alcohol issues and (Chartist) hunger-revolts and “knife and fork” “milk famine” issues that spawned the luddites and trades unions as incomes were falling (some families living on boiled nettles). The new Poor Laws were harsh and the country flirted with revolution as happened across Europe [154]. Meat intake then doubled [155, 156]. Innovative agricultural practices and stock breeding increased production that just about kept up with population growth. The important increase came from imports from the “settler” colonies, and “Atlantic” cod, aided by advances in steam transportation and refrigeration (frozen meat imports to Britain were 200,000 tons in 1900 and 350,000 tons a decade later), with price drops that, for a change, benefited the urban poor, all paid for by profits from the cotton trade and other plantation income [157]. Britain accounted for a huge proportion of the transcontinental and transequatorial meat trade [158]. Repeal of the Corn Laws and repeal of excises on meat also helped the working class [23]. This was a period of significant food price deflation with cheap meat and vegetables attributed to increased productivity from technological improvements (including the cotton gin market but the market collapsed triggering the pellagra outbreak in the Americas) [159]. The influence of luminaries such as Thomas Paine’s “Rights of Man” (1791) [160] and Robert Owen (1813) [161] “*man’s in-humanity to man*” helped let alone Marx and Engels (Condition of the Working Class in England) and the Quaker movement. All efforts contributed to better diet and better (brain) health and longevity.

Infectious diseases particularly Tuberculosis virtually disappeared even if replaced by autoimmune diseases whilst fertility declined completing the first modern disease and demographic transitions [162, 163].

## **12. More recent times: place of markets**

These have seen supply side “Green” revolutions using artificial fertilisers and hybrid or genetically modified seeds with higher yields and higher micronutrient content [164, 165]. This has resulted in continued “Calorieization” and “Cerealization” for the poor but “Meatification” for the rich and aspirant middle-classes. Grain Aid and subsidies concentrate on cereals (some used to feed animals). Rich countries such as the USA and Russia (meat and wheat diplomacy) have turned into major exporters of food with less produced locally putting poor nations at the mercy of international price hikes – as happened with the price hikes of 2008 after the economic meltdown bringing the poorest to the brink of famine [116, 166]. This reversal has paradoxes given Africa has enormous land banks and plenty of sun yet its agriculture would be familiar to those alive at the dawn of Christianity with a lack of irrigation - leaving it ill prepared for already baffling rainfall conditions and friction with nomads as the Sahara marches south. Russia, by contrast, may gain from melting permafrost. This is harsh as Africa contribute almost nothing to climate change even if there is now an opportunity, if supported, to leap frog with clean and electric technology. Rich countries in the Global North, who have greater access to the latest technology and economies of scale (favouring monocrops), and have political power through mega-merged corporations, including meat processors, have by manipulating tariffs and trade rules supported their own farmers with subsidies (such as in the USA and EU). World Bank rules insist on neoliberal free-trade policies for others earlier in development even though this distorts the market place to the benefit of the north.

Pushback on this faultline of neoliberal policies and the “dominium” of neo-colonialism, being grimmer than the “imperium,” was helped by the oil embargo of 1973–4 and the formation of the G-77 as a global south poor nations trade union, achieving some potency including over food supplies [167–169]. However these policies shut out many small farmers (many of them women), from markets who then become impoverished themselves on poor diets [170–172]. This all inhibits local development that needs early protection from cheap imports unless there is a local competitive advantage which there is in the tropics as in “Banana republics” but this is not true of staples or cattle that prefer temperate zones. These ‘meatonomics’ with subsidiaries cause meat deflation in the already rich world aided by ample oil induced efficiency gains.

## **13. Pastoralism – mixed farming**

Pastoralists in Africa are threatened despite producing a high proportion of meat and milk and using geographically isolated range-land unsuitable for crops as common pastureland and water resources get enclosed by developers and transhumance routes (necessary for the best seasonal grazing and to avoid the tsetse fly), blocked so that they get marginalised and cannot afford their own produce and do not get integrated with mixed farming and agro-pastoralism that is not the simplest of evolutionary progressions. There is a false assumption that pastoralists damage ecosystems and equilibria through over-grazing and exceeding the “carrying capacity” of the land. More thought needs to go in to this if meat production is to be increased including optimising vaccination programs [173, 174].



## 14. Reap and sow

The vast grain export as Aid helped farmers in the USA dispose of their surpluses helping short term but did not encourage local development. Some interventions back-fired badly such as peanut farming in Tanzania, apple farming in Nepal and the exacerbation of a food crisis in Malawi [175]. Green developments can be criticised for fueling population explosions rather than credited for alleviating hunger. Import substitution encourages empty calorization of locally processed foods and drinks and is responsible for the “commercial determinants” of ill health and the triple burden of combining diseases of poverty with obesity rather than providing a balanced omnivorous diet [176–179].

The modern period has, despite the above, seen some telling upswings for the majority (such as 1945–1975), that relate to more egalitarian diets with more milk and meat after World War 2 rationing. A 30 years “Trente Glorieuses”, helped by the rise of welfare states, lasted longer than relief from the exigencies of war would explain. Divergences related to more neoliberal policies and less attention to or sympathy for welfare and the incomplete success of civil rights, consumer or cultural power (music, sport) suggest something more fundamental [180–182]. Meat transitions are nevertheless in progress as in China (the high price however favouring the upper and urban middle classes), but are only slowly occurring in India and only arguably in sub-Saharan Africa.

## 15. Meat downsides

Downsides of meat production and consumption given the “Long Shadow” of the livestock revolution and ecological “Hoof-prints” are well rehearsed as are health consequences of meat gluttony from gout onward to (bowel) cancer [183–185]. The knives are out for “hamburger” carnivores and this is not surprising given meat’s green-house gas effects ( $\text{CO}_2$ ,  $\text{CH}_4$  and  $\text{N}_2\text{O}$  [186]), let alone animal rights concerns and risk of food poisoning (e.g. *E.coli*, *Salmonella* and *Campylobacter*), and emergent zoonoses, including COVID-19).

Agri-businesses encroach on land over and above the pastureland that could not be used for crops, that is grabbed and de-forested with little attention to improving the soil long-term leading to desertification -and uses gigantic quantities of fossil fuels as “food-miles” and for artificial fertilisers with consequent loss of biodiversity and insect apocalypses, from pesticide use [187, 188]. Meat markets and farms are under intense pressure, by the poor and the rich (with their exotic tastes), to produce in close ecological proximities often linked to de-forestation increasing risk of (bat) coronaviruses crossing species boundaries.

Rich Americans eat their body weight or more in meat per annum [189]. The poor in sub-Saharan Africa and other places in the “Dickensian” Global South eat negligible amounts. In middle- and low-income countries there is a marked class divide with the rich eating a great deal. Even in the USA or UK, the very poor can live in food deserts and metabolic ghettos reliant on food banks when austerity is policy [190]. In 1962 the average for the Chinese was 6Kg of meat pa but that figure is now 60Kg and rising toward the American average of 120Kg [191].

Ten calories of animal feed (grain, soybean and fishmeal more than grass), produce one calorie of meat and require enormous quantities of land (deforestation), water, oil, artificial fertilisers (fixing nitrogen using fossil fuels and allowing eutrophication), antibiotics (enabling evolution of superbugs and not even given for therapeutic purposes), and pesticides (“silent springs”) [192]. Some relief



comes from less use of ruminants and more of mono-gastric chickens and pigs (badly affected by pandemic induced culls) and plant-based green-marketed foods and drinks as meat and dairy substitutes.

The case against meat is, as a result of the above, strong as a major contributor (30–40%) to greenhouse gas emissions (methane and N<sub>2</sub>O ‘tipping points’ as they are potent but have shorter half-lives than CO<sub>2</sub> but do not have its fertiliser effect), and climate change (1.4°F since 1880) [193]. Meat intake is currently running at 300 million metric tonnes having been 7 million in 1960 and could rise by another 75% by 2050; artificial meats are unlikely to be the whole answer to curb this hunger but other mitigations such as less beef and more insects in diet are possible [194].

## 16. Vegetarianism

Widespread vegetarianism is usually proposed by those in the rich world who have all micronutrients available from other, often supplemented, foods not available to poor economic vegetarians [195, 196]. Embarrassment over meat eating and distancing from the sight of slaughter has a long history dating back to Pythagoras and tied up with concerns about man's place in nature “*Every moving thing that liveth shall be meat for you*” (Genesis ix.2–3), versus “*Take not away the life you cannot give: For all things have a right to live*” (Dryden's Ovid),- up to 17th and 18th C tracts and modern animal rights and animal sentience campaigns and research [197, 198]. There is resistance to vegetarianism culturally, despite “Veganuary,” and converting to some plant-based diets that are heavily processed or engineered corn now ‘super-sweet’ can increase emissions and may have health risks or be too expensive [199–203]. Our new found feelings about stewardship of animals should extend to different geographies as “out of sight out of mind” may shield us emotionally from slaughter houses but should not work for other human-beings on poor monophagic vegetarian diets [204].

## 17. Omnivore's dilemma or dialectic?

Thus, we have contradictory views on meat – is it our maker or breaker? The argument against meat is aimed at those who eat and waste a lot but relatively little discourse is about the needs of the poor and health inequalities and their “killing fields” [205–208]. Perhaps it is less of a dilemma if it is the high variances of meat intake that are the real problem alongside the replacement of vegetables with processed cereals and their products (such as high fructose corn syrup) and that this basic inequality affecting “food for thought” is driving many of the more obvious “Syndemic” problems from zoonoses to climate change to risk of wars and much ill health at the lower end of the income scales [209]. Let us look again at Engel's Law [210].

## 18. Engel's Law: Basic niche construction

In 2011 in Norway (GDP per person \$62000) food budget share was 10% whereas in Chad (GDP per person \$2000) the share was 52%. Poor households have to move up the income scale before the spend on starchy foods falls and the amount spent on the more elastic need for meat rises. It then can fall as the rich become “Flexitarian” in their eating habits (as suggested in Britain by George Cheyne (1733) and by Hippocrates with his “Regimens” much earlier [211].

An unfortunate modern twist, whether poor in America or Africa, is to achieve food security by spending on high fat and high sugar processed foods (or materialistic goods from cars to phones), rather than low density fruit and vegetables that used to supply some micronutrients (such as folate and flavonoids let alone psychoactive compounds in Victorian times when they were cheap) even when meat was unaffordable. This plays into the commercial determinants of disease in “fast food swamps” – with individuals then stigmatised for their life-style rather than the correct label of poor life circumstances [212, 213].

States have traditionally taken some interest up to point 1 providing grain but not point 2 as meat is often felt to be a hedonic “luxury” rather than having a health utility. (Henri IV was an exception in his push for “a chicken in every pot” and Papin’s “New Digester” pressure cooker (1679) helped poor to cook cheap animal products). Inflation is a painful tax on low to moderate income house-holds as are many austerity measures or actual taxes on food and drink – as is sometimes proposed for meat. Many rulers, whether fascist or socialist, have even put conditions on supplying grain to useful workers and starved the “undeserving poor” or dissidents. Exceptions included the Kennedy’s who pointed out “*the obscenity of conspicuous wealth amongst public squalor*” backed up by some intellectuals in a tradition from Aristotle, and glimpsed by Mill, on emphasising a basic need for a good diet before other human attributes can really take off [214–218].

States and markets often ensure the extra meat goes to the urban middle classes (or middling diets) turning Engel’s Law into a political mechanism. Egypt, for example, in the 1970s imported grain for animal feed so that the richest 25% ate four times as much meat as the poorest 25% (and had form as their rulers suppressed wages after the Black Death such that there was no survivor benefit for workers diets, as was seen in most of Europe) [219].

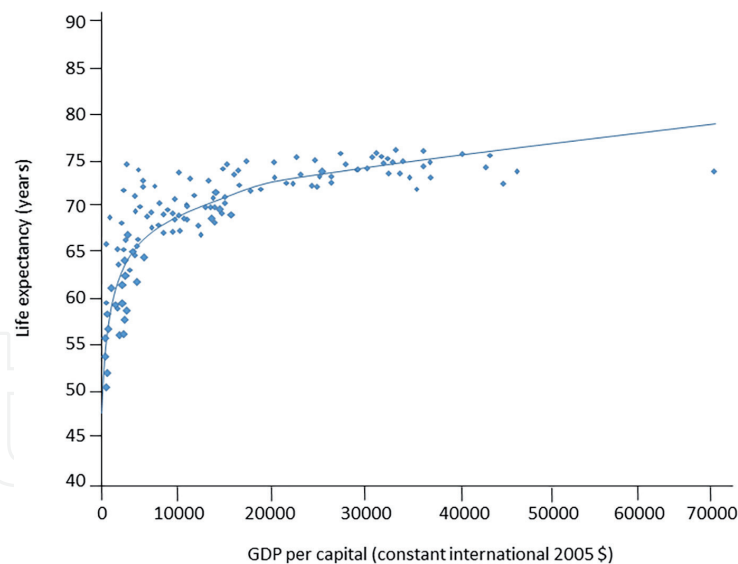
Other societies channel meat to the rich by restricting access to wildlife that normally favour the poor but then becomes an exotic commodity food for the rich. In Samoa hunting pigeons is comparable to English aristocrats hunting deer and as in China and earlier in the West wild delicacies from the land or the high seas were only inhibited when enforced by much stricter conservation laws [220, 221].

## 19. Preston’s curvilinear curves

Meat is an important component of any “unified growth theory” and is an achievable developmental goal. Prestons’ curves suggest that some element of modernity with a low ceiling effect after which there are diminishing returns can improve longevity, health and happiness as measured, for instance, by Happy Planet indices (**Figure 3**) [222]. Low-income poverty traps and middle-income traps (the “Argentina paradox”) with economic divergences may be because Engel’s curves were not satisfied for enough of the people who then can not obtain college degrees [40]. Point 2 on Engel’s curve should be the target to avoid the “hidden hunger” of micronutrient deficiencies [223]. As Kristof has written “*Future generations will be baffled at our heartlessness and our indifference to suffering in impoverished countries*” [224].

## 20. Wealth and health of nations: Lands of milk, meat and honey

Until a reasonable proportion of the population have climbed Engel’s curve either because the cost of grain and meat has fallen (due to increased productivity



**Figure 3.**  
 Preston's curves show the importance of income inequality to longevity and health and happiness and chances of rising up the social elevator. These curves rapidly flatten with a low ceiling effect. Better hygiene and education or medical innovations have been considered causative agents but better diets are the more likely factor. The ceiling effect would accord with Engel's curves and would not be that hard to achieve at a low cost and with more sharing and less waste.

in the agricultural sector or because that country can afford to import more) consumers do not have enough discretionary income and the motivation or “marginal propensity to consume.” [214, 225]. Living from paycheck to paycheck with debt and little capital does not allow spend on luxury goods (that include animal secondary products) or when that is satiated services – in other words the engine of want with a modern economy and a market that appreciates new ideas, technology and institutional governance [226–228]. The rise of consumerism, such as clothes, may however, as first noted by Marshall (1890) [229] and Veblen (1899) [230], be a chief driver of climate change and is fuelled by inequality and status anxiety that might be constrained by more equality. More educated better fed “sympathetic consumers” date back to abolitionists campaigns to reduce consumption of sugar and rum and is now evident in “Fair Trade” movements aware of invisible labourers and animal rights would be the aim resuscitating environmental Kuznets curves claims [231]. Power disparities should lessen with less income inequality allowing all to live in cleaner places and move up on the Great Gatsby curve by allowing all to “Green-up” as environmentalists [232, 233].

## 21. Declines and falls: Milk and meat famines

This underlying process for the wealth and health of nations has in the past led to the intellectual rise of hegemonies in the positive phase – such as the classical “Axial” age that independently at 4 different Eurasian sites in the “lucky latitudes” for domesticates fostered philosophical and scientific advances [234] and falls of Empires as in Ancient Greece and Rome and Mesoamerica from environmental “ecocides” with damage to the soil and to diet [235–238]. Easter and other Island’s “parable” collapses show the close relationship between diet, meat and ecology – eating all the birds led to eating all rats and “slash and burn” deforestation and then on a plant-based diet (as in “peak corn” in Mayan and elsewhere in post-Columbian times), boom bust demographics [239, 240]. Success or collapse can also be seen in terms of ecological succession and transfers between “r” selection and “K” selection

for lower populations of higher quality that has to be driven by omnivorous diets avoiding “catabolic” and negative phases of the cycle that often follow peak inequality in states [241, 242]. Current failures to help a levelling up of under developed countries ignore the role of building human capital based first and foremost on a good diet and was not true of the Tiger economies [243–247].

## **22. National and personal exceptionalism: myths**

The dietary “lurking variable” impact on demographic and disease transitions may have been under-played and the more superficial correlates with educational level or hygiene overplayed [248]. Education is dependent on cognitive skills (of both teachers and pupils), so a better diet must help: as well as fueling innovation. Patents correlate with their owner’s parental income but not with educational opportunities so early diet could be crucial [249]. Good diet must surely be a factor in the “Flynn” effect where improvements in performance on IQ tests improves fast with improved income so cannot be genetic or due to discrimination [250, 251]. Diet may not be any more deterministic than genes but may have more predictive power over success and gene expression by diet is easier to alter than genomes.

The “Great Enrichment” of the globe that began in the Netherlands (“Embarrassment of Riches”) then England is not easily explained by classical or neoclassical economics but had ideas from the well-fed “Bourgeoise” as their real “steam” power as a greater mass of people “could have a go” at innovation and invention - with better institutions and capital accumulation as secondary reinforcements to avoid intellectual “enclosures” from patents and monopolies [252, 253]. Fogel championed diet as being the prime mover with a well-nourished well paid workforce being a pre-condition for development [254–257] and has, at times, been the policy of the United Nations [258] as advised by others [259, 260]. Mechanisms that go beyond the need for calories with micronutrients create virtuous cycles: lessons on vicious cycles come from pellagra [261, 262] - affected “cotton” states still scored the lowest for social and economic well-being over 50 years later and the highest for incarceration [263].

## **23. Less infection, lower fertility, autoimmunity, longer lives**

Better diet improves host resistance as even if not catching an infection people are less likely to die - TB and measles are good examples - as well as increasing crystallised intelligence from living longer. Not catching TB or other “Old Friends” because of better diet may contribute at least as much as better hygiene to the switch between chronic infections and auto-immune diseases so characteristic of modern states. Furthermore fertility falls, but quality of offspring improves; this being a non-coercive form of population control and age structures from dividend to drag that is a mixed blessing in some economies with see-saws between birth control and infertility clinics, but an advantage to others, many in the south such as in Nigeria where population booms are dramatic and could eclipse the population of the United States, so once again meat moderation may be best to avoid “arcs of instability” [264, 265].

## **24. Clean, safe meat and justice**

Reducing the variances in meat (and milk, fish and shrimp) intake perhaps to a mean of around 30–50 Kg per person per annum may be the way forward through

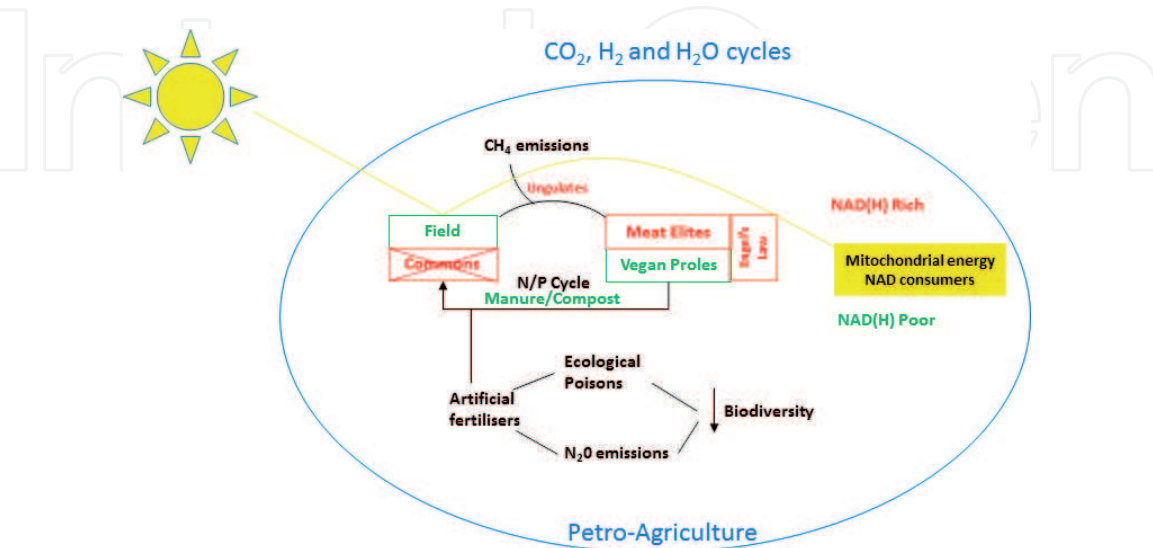


more sharing and less waste and better husbandry but is still, in essence, a power battle [266]. This meat pathway should be made cleaner and use emerging meat technologies as they become available and affordable. Risk of emergent zoonoses should be reduced. Only then would the lottery of one's life chances so related to geography, including within states, and discrimination and snobbery often based on educational achievement even if fronted by the identity politics of the day, such as skin colour reduce or at the least enter a new chapter [267, 268].

Redistributive food justice as in school meals programmes (as advocated by the Black Panthers and opposed by the FBI who understood the power of food), would deliver more “bang for the buck” than high military and security budgets or even the high healthcare costs for those in their last few years [269]. Free school meals remains a marker of deprivation in many rich countries that correlates intellectual attainment and college entry: only when a strong dietary base is satisfied would a meritocracy make sense [270, 271]. A backlash would doubtless need to be overcome as previously disadvantaged people become more assertive as seen with the Wilmington insurrection [272] (1898) or “Tulsa” riots on “Black Wall Street” (no food desert with 38 grocery stores), who stopped seeing themselves as second class citizens to the irritation of societies status quo ante [273].

25. Metabolism and free energy scales: Prometheus unbound

As Stephen J. Gould said in 1981 *“Few tragedies or injustices can be more extensive than the stunting of life by a limit imposed from without, but falsely identified as lying within.”* Gould pointed out that intelligence like height could have high heritability within a family yet be very sensitive to poor diet in the population. Our propensity to virtue or violence may also have a lot to do with whether we are toward the top of Engel's curves and full of energy and not too worried about being displaced [274]. A metabolic and more classic liberal approach, such as of Mill and Smith, that encompasses ethical commitment to others welfare is needed [275–277]. Ultimately this may all be about flux (as noted by Heraclitus) and thermodynamics turned on it's head by use of oil. Our predicted needs are for NAD(H)-based internal (and external) energy gradients. Josiah Gibbs (1878) and followers understood that



**Figure 4.** Metabolic health and metabolic ghettos and rifts seen from a NAD(H) perspective. Poverty may one day be defined in biochemical not sociological terms, as NAD deficient. NAD deficiency then exacerbates infections, chemical pollution, stress and poor education to which the poor are more exposed, particularly when residentially segregated.

chemiosmotic proton motive forces in mitochondria and chloroplasts were key as free energy usage based on Hydrogen ((H) carried by NAD and stored as ATP) connects our brains to the great cycles of life on a symbiotic planet connecting photosynthesis to respiration and combustion (**Figure 4**) [278–281].

## 26. Metabolic rifts

Local farming “100-Mile Diets” (as was normal until recently) and less deforestation or loss of mangrove swamps and less mono-cropping and better ground cover (absorbing CO<sub>2</sub>) and care of the soil reducing desertification and dustbowls with less artificial fertilisers and lower transportation needs will help. Humus and the soil are both chemical and biological systems (Darwin’s worms (1881) and their microbiome) with complex interactions. Losing the “commons” pastureland caused issues from the original metabolic rift between humans, animals and nature, as proposed by Rousseau and Marx, such that manure or compost does not get returned to the soil through to modern views on the circular biomimicking economy [68, 238, 282, 283]. Even losing the right to produce your own natural greenhouse gas emissions is part of a multiple “Enclosure” movement making everything a commodity that is entrusted and traded for a profit in the market but not returning proceeds to the underpaid whose diet then loses out [284, 285]. A symptom of capitalism is that food chain workers on the land are in the frontline at food banks. Significant “Schumacherian *Small is Beautiful*” locavore counter-movements emanate from community peasant farmers, such as “La Via Campesina”, “Seikatsu” (allotments and “Dig for Victory” in WW2 that included chickens and pigs), with experiments in countries such as Cuba and slow food movements although they rarely major on meat and milk [286, 287]. Gardeners and horticulturalists and not only industrial farmers, have much to learn about sustainability tailored to the local landscape - desperately poor farmers will mine their land for survival (and pastoralists invented zero-grazing stall fed cattle), as often as capitalists in tendencies that date back to the bronze age as first noted by Xenophon in the fourth century BC [288].

A return to universal common arcadian pastureland is too big a Utopian ask but the idea of “Sitopias” with a “Humanomics” and restraints on the “invisible hand” with a “doughnut” economy allowing meat for all in a resilient panarchy - meat for the rich is subsidised - is on the cards and is not a zero-sum game reducing many of the current risks to ourselves and to the planet [289, 290].

## 27. Mayday: wars and pandemics?

*“If a free society cannot help the many who are poor, it cannot save the few who are rich”* was the socially sustainable message from president J.F. Kennedy’s inaugural back in 1961. The alternative of an increasingly unequal world and further geographies of poverty with new class structures and aggrandizers as global warming damages many agricultural systems would create a vicious cycle of biodiversity loss, even our “good-selves” [291–293]. Stressing of the meat supply risks emergent zoonoses - and war [294–296]. Dyer (2021) writing on wars from resource stress points out that primate and human rustling and outright wars, from the fierce Yanomamo on, were often over meat [297]. Livestock raiding may be a rite of passage for some but easily escalates to predatory raiding and has a lethal synergy with oil interests that can lead to geopolitical conflicts.

Revolutions and wars were often triggered by an excess of an elite class colluding with the hungry poor. Aggressors cottoned on to the value of starving their

opponents in the American Civil war and World Wars - whose original purpose (like all empires as noted by Sophocles) was to gain pastureland ("Lebenstraum"). (Napoleon's earlier serial mistakes had been sending grain to Britain thinking that the gold spent would be more destructive, then ignoring his own supply lines in Russia and again in the Haitian revolution of the enslaved [123]). Civil wars are vicious often starving opponents as is being seen now in South African insurrections that bring access to food to its knees with child support coming nowhere close to satisfying – and tragically not representing the ideals of Mandela [298]. Despite somewhat different histories this Anglo-Dutch colony (note the extraordinary cattle-killing episode of 1857) and the American issues south of the Mason-Dixon line, including the Caribbean and down to the Rio de la Plata, are the hard core of white supremacy and both being prone to pellagra are key to our argument – as is also supported by the Australian experience [299].

Worse could come with a dystopia of climate change with droughts or floods affecting global food production first in the southern tropics and subtropics (often affecting pastoralist first who have to move), and triggering forcible attempts to break down walls (the fall of the Berlin Wall was triggered by meat queues and "solidarity" revolts), constructed as enclosures of rich gated communities protecting their own food supplies, is not too hard to imagine [300]. The end of the Cold War changed the political worry to migration and "the Coming Anarchy" from movements from low meat zones (as has been the case for all major human migrations from "Out of Africa" on) with terrorists joining up for remuneration as much as religious fervour to feed their families [40]. Water shortages have led to migrations but cooperation between states have often mitigated friction so far but remains a danger - the same might happen if meat was equilibrated increasing resilience [301, 302]. Wars and even "wars" against pathogens, often blamed on foreigners fueling xenophobia, is not an answer [303]. Relying on vaccines does not address the underlying driver but a more ecological and veterinary "One Health" approach with an emancipated public health concentrating on natural resistance from a good diet and safer sources avoids "Red Queen" evolutionary dynamics - or microbes will indeed have the last say [304, 305].

## 28. Conclusion

What we have tried to demonstrate is that, despite the importance of meat in our evolution and sharing of meat during our long less hierarchal hunter-gatherer phase, since recorded history began getting a grip on Engel's curve has been rigged for any but the rich and this mismatch has caused much inequality, disease, poor demographics and friction. Border wars and pandemics [306] would be a tragic own goal for rich and poor alike, given the political and societal impacts, if we cannot develop a new concept of the world from "emancipatory catastrophes" and cafeterias for all, not banquets for the few [40, 307]. These natural experiments and lived experiences aggregate evidence and by appreciating our "Bayesian" priors and precarity of the poor (all precarious), we can plan better for the future. Covid gives a current example of the poor being put at risk of late onset ailments from commercial 'bliss points' that then become risk factors as well as the hunt for meat leading to unsafe farming practices allowing microbes to jump species (as also happened with the bovine and human prion disease epidemic). We have been mean, sometimes inadvertently, about recreating our ancestral meat commons and stunting others lives in order to be in charge then racialising conduct and cognition. Not thinking like a "species being", but as classes or nations, puts our own species under threat let alone endangering many other species with extinction [308]. As Lewis Carroll said (in *Through the Looking Glass*, 1872) "*the question is, said Humpty Dumpty, who*

*is to be master- that's all*". Being more generous is to be more masterful over the longer term and more "Nordic" [309] and as with ancient potlatches would avoid the dangers of surplus wealth in general, let alone the specific dangers of meat and nicotinamide overload, as money has to be spent somehow often propping up the "rentier" class or in dangerous arms races or housing or stock market bubbles bailed out by governments at the expense of the poor, as pointed out by Bataille (1949) [218, 310]. Only a proportion of capital is spent in useful reinvestment, research and development but is hoarded by the 1% [311] or as Galbraith said earlier *"beyond doubt wealth is the relentless enemy of understanding"* echoing long held biblical concerns about 'Mammon' and 'Paradise Lost'. A more anthropological vision of the world that questions the least questioned assumptions, as Paul Broca (a 19thC neurologist) suggested, would accept the lifetime importance of a good diet, with nicotinamide pathways as the "secret sauce" rather than carrying on with the disadvantaged "left behind" being subject to the most unlikely explanations for their plight and discrimination and snobbery from the elites - that wastes so much human talent and could cancel race matters that already are not an issue amongst well fed well educated elites [277, 312].

## Acknowledgements

We would like to thank Queen Elizabeth Hospital Birmingham Charity for funding this study.

## Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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