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Review Article

Uncivilised Genes: How A Greater Understanding of the Evolutionary Determinants of Health Could Improve our Urban Wellbeing

Gustav Milne [1*]

[1] Institute of Archaeology, University College London, 31-34 Gordon Square, London WC1H 0PY, UK

This paper is concerned with the prevention or containment of World Health Organisation's ten most common fatal diseases or conditions in modern urban populations. This ambitious target could be achieved over time given a greater understanding of the *Evolutionary Determinants of Health*.

The underlying concept lies in our evolutionary biology. As recent genetic research has shown, we share 98% of our genome with the chimpanzee (*Pan troglodytes*), and thus have a common ancestor, from which our lineage diverged some 6million years ago. Subsequently the human branch adopted bi-pedal hunter-gatherer-style cultures, living in small tribal societies in the wild, wide open spaces. Through the unbending rigours of natural selection, a particular physiology, dentition and metabolism developed together with their associated digestive and respiratory systems as well as associated psychological traits. This part of our DNA directly supporting those ancestral lifestyles is termed our *Palaeolithic Genome*: it still remains with us, largely unchanged, although culturally we have evolved at an electric pace. There is therefore a mismatch between our modern urban lives and our basic biology, manifesting itself in the alarming increase the incidence of obesity, diabetes, various coronary issues and cancers. Significantly, such problems seem to be rare in non-urbanised societies, such as the Kitava community in Papua New Guinea as a detailed study by Dr Staffan Lindeberg has shown.

If our urban lifestyles, architecture and even town plans were reconfigured on evolutionary-concordant lines, our health, immune systems and wellbeing would be significantly enhanced. Uncivilized genes can materially improve tomorrow's civilisations.

Ancestral diet	**Evolutionary Determinants of Health**
Human evolution	**Lifestyle embedded activity**
Palaeolithic genome	**Town-planning**

The town is not our natural habitat. But for the first time in human history more people live in cities than in rural settlements: our global urban population of 3.4 billion is set to double by 2050, as we create artificial environments on an unprecedented scale [1]. Although there are major benefits in urban living which we all enjoy, there are also costs, such as the fatal increase in the "Urban Lifestyle" diseases that have become depressingly familiar.

Our study concerns that mismatch between our palaeolithic genome (designed to support an active hunter-gather culture) and modern urban living. For over 3m years, we evolved as hunter-gatherers, living off the land in small tribal societies, developing a working relationship with nature. Culturally, society has subsequently developed at a remarkable speed. Anatomically, however, we remain much as we were before towns developed, or even before large-scale farming was adopted 5,000 - 10,000 years ago [2]. There is therefore a profound dichotomy between the world we currently live in, and the one we are genetically, metabolically, physiologically and psychologically designed for. If we are to contain the sick-city syndrome, then the lessons of human evolutionary archaeology should become central to the reconfiguration of urban lifestyles and for planning the next generation of cities: tomorrow's megaurban landscapes should be based on evolutionary-concordant designs if we are ever to adapt successfully to them.

To help address this challenge, the **Evolutionary Determinants of Health** programme was launched at University College London in February 2014, at the "Urban Paradox" conference. It brought together archaeologists, architects, town planners, microbiologists, and academics dealing with transport studies as well as public health, a consortium reflecting the project's multidisciplinary nature. Some of the issues raised at that conference are discussed in this paper, and set in a wider context [3].

Our programme identifies the positive physiological and psychological components of an "ancestral lifestyle" regarding nutrition, activity regimes, societal issues and engagement with nature (essential for an effective immune system). The next stage was the development of evolutionary-concordant protocols for personal and institutional health behaviours that can be readily adopted in a 21st-century context, as well as urban design and town-planning guidelines, a particular focus for the February conference.

Urban Wellbeing: Social Determinants of Health v Evolutionary Determinants of Health

There are complex social, cultural, political and economic factors that contribute to the pronounced health inequalities in our modern urban society, as Professor Sir Michael Marmot's *Social Determinants of Health* team has demonstrated. Good health and enhanced wellbeing tends to improve with social class [1] Those living in the most deprived areas of a city like Glasgow, for example, have a life expectancy that is 12 years shorter than their neighbours in the more affluent districts: it is such social inequalities of health that people are born into that need to addressed by political, economic and cultural change [4].

Corresponding author: Gustav Milne, Institute of Archaeology, University College London, 31-34 Gordon Square, London WC1H 0PY, UK, Tel: +44 (0)20 7679 7495; Fax: +44 (0)20 7679 7495; E-mail: g.milne@ucl.ac.uk

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There is however, an even more fundamental mismatch which exists between our palaeolithic genome and modern urban living. It is on this and related issues that the Evolutionary Determinants of Heath programme focuses: facing up to the challenge presented by the Sick City Syndrome, the alarming modern rise in obesity, coronary heart disease and type 2 diabetes and other associated problems and conditions. Unlike the Social Determinants of Health, the immutable Evolutionary Determinants of Health that we are all born with cannot be changed. It is our towns and urban lifestyles that must be changed instead. This report summaries evidence-based research that demonstrates why an evolutionary concordant approach to modern urbanism is essential, and suggests ways in which it might be implemented.

An Urban Advantage?

The so-called "urban advantage" – the assumption that those living in towns have greater health benefits than their rural neighbours- should not be considered as a foregone conclusion: not only do "rich and poor live in different epidemiological worlds even in the same city" [1], but different aspects of living (eg diet, levels of physical activity) might be demonstrably more "healthy" in the country than in a contemporary town. Indeed, for the new urban populations in expanding 18th and 19th-century western conurbations, outcomes such as average age at death or levels of infant mortality actually increased before sanitary conditions began improving in the later decades of that period. In theory, as income per capita rises, so too should life expectancy, based on a steady reduction in death rates as well as birth rates. But the global picture is rather more complex than that. Although stringent public health measures and much improved health services have removed many of the initial scourges of city life such as cholera and typhoid, those evils seem to have been replaced by an increasing catalogue of diseases and conditions whose presence and profile were far less significant in the previous era.

The World Health Organisation lists the ten most common causes of death in modern urbanised societies, a dismal list that includes coronary heart disease; stroke/cerebrovascular disease ; lower respiratory infections; chronic obstructive pulmonary; trachea/ bronchus/ lung cancer; diabetes; breast cancer; Alzheimers/ dementias and colon/ rectum cancers [5]. Many of these new villains are a direct product of our current urban lifestyles, that is, they are largely part of a culture of our own making, if the compelling evidence of a detailed long-term project in Kitava, Papua New Guinea is to be believed. Staffan Lindeberg's research shows that ALL those diseases and conditions were rare or non-existent in an un-urbanised communities that maintained an 'ancestral' life-style [6].

It is accepted that we all have to die from some cause some day. Nevertheless, it is significant that 52.1% of the modern most urbanized global population died of conditions or diseases that were rare or non-existent in the non-urbanised population from Kitava. Arguably a case to be made for a Non-urban Advantage. This contention is strongly supported by palaepathological research on cemetery sites [7]. Archaeologists have shown how the deterioration in our collective health began with the transformation from ancestral practices to farming and then to urbanisation, some 5,000 to 10,000 years ago. The domestication of plants and animals during the Neolithic period heralded major changes in the human diet and activity regimes, and thus in our wellbeing. Skeletal research shows that the introduction of intensive farming saw a noted increase in dental caries, dental defects, tooth loss; trauma, metabolic and joint disease. It is also associated with the first evidence of tumours, anaemia, diffuse idiopathic skeletal hyperostosis (DISH, a proxy for obesity), osteoporosis, osteochrondritis dissecans, as well as infections such as osteitis and periostitis of sinuses, ribs and skulls. The Roman invasions of Britain in AD 43 not only introduced the civilising concept of urbanisation to these islands, but also scurvy, rickets, osteomalacia, Reiter's syndrome, gout, ankylosing spondylitis, rheumatoid arthritis, psoriatic arthritis, septic arthritis, tuberculosis, osteitis, poliomyelitis and leprosy. None of these diseases or conditions were seen in the prehistoric, largely un-urbanised tribal populations that lived here before the Roman's urbanising culture arrive [8]. Arguably, urbanisation was (and often remained) a mixed blessing.

Reverse Approach

Modern medical research tends to target specific diseases, their potential triggers, or the effects and impacts of potential pharmaceutical remedies for particular conditions. It must be stressed that major benefits have resulted from this highly focussed approach to the molecular and physiological mechanisms underlying what is termed the proximate mechanical cause of a particular condition. Our project, however, takes a different perspective, looking at the major challenge presented "western life-style diseases". Given that the genetic make-up (our palaeolithic genome) is basically the same for the Kitava population as for the contemporary urban populations, it follows that the profound difference in the most common causes of death between them must reflect significant differences in diet, activities and/or environment. It seems that the more urbanised we become, the more susceptible we are to adverse conditions of our own making.

Instead of considering why and how modern city dwellers contract coronary heart disease, the reverse approach is adopted here: the question we should be asking is why the Kitava population do **NOT** suffer from that or any of the other cancers and conditions that are now all too common. Rather than mounting attacks on these conditions individually, the reverse approach enables all these diseases to be considered as a group, the "Sick-City-Syndrome". Faster and more effective progress might be made if the root cause of the syndrome is addressed upstream at source, rather than waiting for major flood events downstream.

We need to reconfigure our diet, our activity regimes as well as our social and urban environment so that our Palaeolithic genome is seduced into operating "as normal", rather than continuing to endure the (literally) unnatural demands made upon it that have such devastating consequences for our health. Once the effective "healthy" differences between the "ancestral" lifestyle and the modern urban lifestyle have been identified, then evolutionary-concordant lifestyles can be devised. Proxy behaviours and simulated environments can then be introduced into our 21st century towns, allowing us to enjoy the benefits of urbanisation while reversing such evils as the rising obesity epidemic with all its many associated problems. A combination of personal and institutional health behaviours coupled with more evolutionary-concordant public health programmes are therefore being developed, building wherever possible on current initiatives and relevant research already in the public domain.

Ancestral diets

The environmental niches that herbivores, carnivores and omnivores inhabit are reflected in their different physiologies and digestive systems and in the foods they are specifically designed to collect and consume. Although our nutritional needs remain largely the same as they were 3m years ago, a modern urban diet with a high volume of over-processed foods and added sugars now places an undue burden on our digestive systems and thus upon the National Health Service. It is argued here, not that adopting a proxy "ancestral diet" is good for you (it's normal), but that NOT adopting such a regime is demonstrably bad for you.

There is an extensive (and ever-expanding) literature on this subject. One of the first studies that identified links between 'primitive'

physiology, diet and modern man was published by the American dentist Weston Price in 1938. Although the central focus was on dentition and dental diseases, it ranged over other related issues and five continents, producing one of the first major scientifically-compiled studies to advocate the positive health benefits of an ancestral 'native' diet over a modern one [9]. In the UK, the rationing of food -especially sugar- during WWII imposed what has been described as "a virtual peasant diet" on an entire population [10] home grown fruit and vegetables, however, were not rationed, and by 1952 the nation as a whole was actually healthier than it was in the 1930s. In the West, the period following the deprivations of the war witnessed a major expansion in food production and processing, coupled with a general consensus that *more* food –from whatever source- was the key to good living. But not everyone agreed: the gastroenterologist Walter Voegtlin who studied Colitis, Crohn's disease and Irritable Bowel Syndrome, suggested that a diet based on that enjoyed by ancient hunter-gatherers would cure many of the ills he faced in his surgery [11]. By 1985, that message had been taken forward by physicians S.Boyd Eaton and Melvin Konner from Emroy University [12-14]. Perhaps the most comprehensive study inspired by Eaton and Konner's influential work was initiated in 1989 by the Swedish doctor Staffan Lindeberg. The *Kitava Study* --monitored an island population in Papua New Guinea, which had no incidence of stroke, ischemic heart disease, diabetes or obesity [15]. His comparison of the Pre-agricultural diet in relation to modern dietary regime mounts a highly persuasive argument in favour of the former [6], supported by no less than 2034 references.

Not only has medical research studying the benefits of such diets increased over the last quarter century, but so too has the archaeological and anthropological evidence that underpins that work, clarifying and expanding our knowledge of the dietary regimes in question [16-22].

These and many more such research studies demonstrate that our physiology was and still is designed to collect, eat and digest a daily complement of fresh food, vegetables and fruit: the evidence-based research discussed here suggests that our digestive systems have not yet evolved beyond that of the hunter-gatherer. To take one example: a study of 65,226 individuals included in the Health Surveys for England 2001-2008 studied the value of eating not just five but at least seven portions of fresh fruit and vegetables a day: this was linked to a 42% lower risk of death from all causes, a 31% lower risk of heart disease or stroke and a 25% lower risk of cancer. It was the vegetables that seemed to provide greater protection against disease with each daily portion reducing the overall risk of death by 16%, a salad portion by 13%, and each fruit portion by 4% [23]. It is thus possible to argue that not only that eating more vegetables increases the chance of a longer life, but that the more a diet diverges from a palaeolithic norm, the shorter that life is likely to be.

Lifestyle-embedded activity

The evolutionary determinants of health are also concerned with the modern health problems directly caused by diminishing activity levels in urban cultures so different from those which we were designed for. Research conducted in North America addressed the question of how less active modern populations are than in the past. The activity levels of four groups of school children were compared: one from a town, another from a neighbouring rural community. The results from these groups were set against children who were often leaner, stronger and with less evidence for obesity. They were from an Old Order Mennonite community with a lifestyle that had changed little over the last 60 years and an Old Order Amish farming community where ownership of cars, bicycles, tractors and telephones are still not permitted, representing a lifestyle commonplace a century ago. The study shows that modern lifestyles can be associated with pronounced lower levels of moderate- and vigorous-intensity physical activity. Although this shortfall could be made up with eg additional sports, it was noted that the prime difference seems to be the physical nature of lives dependent on many manual chores. It was these **lifestyle-embedded physical activities** -rather than additional jogging or organised sport- that most readily provided the levels of exercise required for a normal "healthy" life [24,25].

James O'Keefe's team extended that debate, discussing elements of ancient hunter-gatherer activity regimes relevant for evolutionary-concordant modern urban lifestyles. The report included observations from Kim Hill, who worked with the Ache hunter-gatherers of Paraguay and the Hiwi foragers in Venezuela [26,27]. It concluded that the human race is genetically adapted for a life of routine light to moderate activity essential for survival (walking, lifting, carrying, bending, climbing), rather than for long sedentary periods. The actual tasks accomplished in a "normal" hunter-gatherer's day could vary, depending on the level of hunger, seasonality, weather or terrain. Nevertheless, it seems that the typical daily distance covered by human locomotion would be in the range of three to ten miles. The necessary daily activities would require an average energy expenditure of between 3,000 and 5,000 kj, up to five times greater than many modern sedentary adults [12].

Given those physical demands, hunter-gatherers were usually lean and rarely obese: this reduced trauma to their joints and minimized diet-induced inflammation. A body designed for a life of regular walking, bending, lifting, and carrying heavy loads (wood, water, food, children) needs to undertake such activities regularly: if the skeleton is not so used then it becomes susceptible to osteoporosis, osteopenia or sarcopenia [26,27].

Most walking and running in the Palaeolithic would have been done barefoot on grass in the open air (thus benefitting from additional vitamin D) rather than in the confines of an air-conditioned gym. Such ancient activity can be contrasted with urban jogging on concrete in expensive, restrictive running shoes. Given conditions such as shortening and stiffening of the tendons and foot ligaments, plantar fasciitis, ankle sprain, Achilles tendonitis, hamstring tears and lower back pain, questions need to be asked about the overall health benefits of such modern artificial exercise [28].

Urban greenspace

The issues of outdoor exercise lead directly to the discussion of urban greenspace and biophilia. We cannot all live in a rural wilderness, so how can that most artificial of environments, the town, be reconfigured to better fit our biology? The role that parks, gardens, allotments, sports fields, tree-lined avenues and window boxes play in our urban lives is of major significance. There is evidence to suggest that urbanisation leads to rising rates of psychosis and depression [29]. Mathew White suggests this problem may relate to the "detachment from the kinds of natural environments people evolved in and are best adapted to" [16,30]. White's study suggests that individuals felt a greater sense of wellbeing in urban areas with more greenspace; conversely, those in less green areas showed higher levels of mental distress and lower life-satisfaction ratings. Increasing the amount of greenspace in urban settings would thus have marked aggregate health benefits [16].

But was that simply because healthier, more affluent people lived near parks? The research by Richard Mitchell and Frank Popham worked with a database selected from the UK records of 40,813,236 persons below retirement age. Significant positive associations were recorded between all those, regardless of income, when proximity to greenspace was measured against all causes of death and against circulatory diseases. It seems that living close to a park has a beneficial impact on health regardless of salary: urban "environments which

promote good health may be the key in the fight to reduce health inequalities" [31]. Such research underpins part of thinking in the Green Paper prepared for the proposed "Nature and Wellbeing Act" that may be put before parliament in 2015.

Living near a "natural" environment is therefore closely associated with long term health benefits, but why should that be so? The answer lies in the remarkable research conducted by micro-biologist Professor Graham Rook and his colleagues. His explanation, going deeper than landscape appreciation and its temporary psychological uplift, and focuses on a key component of our wellbeing. In addition to close consideration of our nutritional and activity regimes, continuing good health also requires an effective immune system. Rook has shown that it is from direct contact with plants and animals that we derive the macro-organsisms, micro-organisims and microbiota that live and thrive on our skin or in the gut. We are not born with these microscopia: they are all derived from the external environment after birth, from the soil, from plants, from animals, from the air or from contact with other humans. For millennia they have been invading and inhabiting humans and their predecessors and, crucially, have co-evolved roles in the regulation of the human immune system. Some were benign, others were potentially harmful, but needed to be tolerated if the benefits were to be experienced. These tiny organisms work together to provide our own individual ecosystem service: without them, our susceptibility to allergies, autoimmunity and inflammatory bowel disease is greatly increased [32-34].

The very process of urbanization itself can be detrimental to our body's ability to fight infection and disease. Epidemiological research has now shown that children exposed to farms and farming environments have increased protection against the development of asthma and of allergies in childhood, when compared to those living in less rural environments [35]. For those born in towns in high-income countries, it seems that many will face increases in chronic inflammatory disorders, caused partly by the failure of the immune system to respond appropriately. This seems to be because an urban child's immune system, having only had minimal exposure to microbiota, will not have "learned" to recognize or differentiate between beneficent strains or harmful pathogens. The poorly-educated immune system thus makes inappropriate responses to what it wrongly thinks are attacks on the individual, which can lead to autoimmune diseases such as multiple sclerosis. Such incorrectly identified "attacks" on otherwise harmless allergens can trigger allergic disorders such as hay fever, while those in the gut can precipitate ulcerative colitis or Crohn's disease [36].

This research provides a major reason why towns (or more correctly, reduced engagement with nature in an urban environment) could be bad for our physical health: we still need the microorganism that only animals, plants, trees and soil can provide. Growing up in a city that has concreted over the good earth and filled its buildings with conditioned air will not support the immune system. On the other hand, living close to urban greenspace, gardening, walking outdoors, growing up with pets, could ensure that you absorb sufficient microbiota to support a robust immune system. Graham Rook makes particular mention of pets, noting that the exposure of humans, especially children, to animals such as dogs "seems to provide some protection against allergic sensitization and allergic disorders" [36]. He argues that humans have coevolved with canine microbiota ever since the domestication of the dog, and possibly even earlier than that.

Evolutionary-concordant town planning

As far as our palaeolithic genome is concerned, we are still hunter-gatherers. To function effectively- ie normally- our digestive system still needs fresh food and water, since it cannot accommodate over-processed foods or too much added sucrose. Our lungs still need fresh air and cannot cope with diesel particulates and toxic emissions. Our physiology still needs regular daily exercise and our immune system still needs regular contact with plants and animals. Those are just some key evolutionary determinants of health that must be taken into serious consideration on an individual level – the personal protocol. That said, town planners and architects also have a responsibility here, since the built environment can be made to reflect those immutable determinants of health and social wellbeing in its building design, its greened streets, the provision of urban greenspace, and in how the town plan itself can place human locomotion (rather than the car) at its heart.

Polluted urban air

A key evolutionary determinant of our health concerns our lungs and respiratory system. They were designed for clean, fresh air, certainly not for polluted conurbations, especially those with major industrial complexes and too many cars, or indeed, the burning of fossil fuels. When London's homes were heated by coal fires, it was infamous for its "pea-soupers", its foul toxic fogs. The *Great Smog* which blanketed the city in December 1952 was unprecedented, however, and it is claimed that it caused the death, directly or indirectly, of at least 12,000 people. It was the catalyst for the pioneering Clean Air Act of 1956, that introduced 'smoke control areas' in cities where only smokeless fuels could be burned, starting a major movement away from solid fuels for domestic heating to a much greater reliance on electricity and gas.

But it is not just high levels of sulphur that are anathema to our ancient lungs: are they also unable to cope with traffic fumes from diesel engines, for example. A report for DEFRA published in 2014 has shown that the emissions of Nitrogen dioxide and the tiny diesel particulates from diesel-powered vehicles have risen steadily over last 15 years. It goes on to suggest that 29,000 premature (that is, avoidable and unnecessary) deaths in Britain may have been caused by such emissions. That is well over twice the number of deaths attributed to the Great Smog of 1952. Diesel fumes also raise the risk of heart attack and stroke as well as exacerbating asthma attacks and have been implicated in the development of lung cancer and tumours of the bladder [37]. Two recent studies, including one at Kings College London, paint an even worse picture. One, based on work in Tower Hamlets and Hackney, suggests that air pollution is responsible for permanently stunting the growth of children's lungs, while the other shows that, where pregnant mothers are living in the more polluted areas, the damage actually starts in the womb. Toxic particles and gases emitted by diesel engines appear to be the principal culprits (Leake 2014). Regrettably, the increase in diesel vehicles on London's roads has been a significant contributor to poor air quality in that town since on average a diesel vehicle will emit 22 times as much particulate matter and at least four times as much NOx as a petrol equivalent [38,39]. It has been calculated that the majority of NOx comes from road transport, mainly from cars (28%), heavy goods vehicles (18%), buses (16%), large goods vehicles (9%) and taxis (3%) (TfL 2014). Nitrogen dioxide concentrations (arising from NOx emissions) still widely exceed EU limit values on roads in inner and central London, a grim picture that is replicated in many other large, densely-built conurbations in Europe [38,39].

Measures being taken to render London's air more evolutionary-concordant by reducing the offending emissions include fitting filters to London buses, retrofitting or retiring older buses and taxis, while over 24,000 homes and public buildings are to be remodelled with energy efficiency measures to reduce their emissions [38,39].

Human locomotion

It is now clear that regular physical activity in fresh air in a green or greened environment is an essential component of a normal evolutionary-concordant lifestyle. As part of the continuing

programme to promote activity levels, a series of guidelines have been published [40-44]. These reports also detail how regimes involving lifestyle-embedded activities such as walking and cycling might be better built into the urban environment [39,45]. This requires more than just updating Ebenezer Howard's treatise on Garden Cities, first published in 1902, in an age before the automobile ruled. Settlements today are very different animals, in scale, function and population density. It is not just poor dietary choices that can lead to poor long-term health, since most of us also need to lead less sedentary lives. What is clear is that the design of our public transport system, our buildings, our streets and our townscapes can significantly help us achieve that goal, and get us back to the levels of daily exercise that our palaeolithic physiology expects. Walking or cycling to and from school or at least for part of the daily route to work and back would be a simple solution to reducing weight and health problems while providing significant psychological uplift [46]. If such a programme were adopted on a city-wide basis it would also reduce car travel, traffic congestion, air pollution, carbon dioxide and diesel emissions, noise levels and road traffic accidents. It has also been calculated that if Londoners chose NOT to adopt an evolutionary-concordant regime of 150 minutes of physical activity per week, then such abnormal behaviour could lead to 4,104 more premature deaths; 1,528 extra cases of coronary heart disease; 778 more cases of breast cancer; 474 more cases of colorectal cancer and 44,620 more cases of Type 2 diabetes [39].

To encourage such major cultural changes, modifications to the townscape are required: people prefer to walk in city centres with wider pavements, pedestrianised routes, well-designed shared spaces, or through parks, quieter or greened back streets, with good street lighting and CCTV at night time. Roads that pass through shopping centres should have traffic calming measures or a 20mph speed limit. Many cities are now implementing designated cycle networks (with the attendant cycle racks, signage and major road crossing points), and work has begun on extending that principle to pedestrians. In Wales, Cardiff is developing its *Walkable Neighbourhood Plan*, identifying a network of streets and parks that serve key local destinations to positively encourage walkers (*Keep Cardiff Moving* website), a programme developed as part of the *Active Travel (Wales) Act*. The associated guidelines (Welsh Government 2014) appeared in the same year that Lucy Saunders and her team published their highly impressive Transport Action Plan for London [39].

Active buildings

Designing a town that encourages and facilitates physical activity is not just about external spaces, streetscapes and the public realm, but also concerns the internal workplace design. There is clear evidence that an abnormal sedentary office life is linked to increased health risks. The pioneering study of the comparative health of 31,000 sedentary bus drivers and their far more active bus conductor colleagues published over 60 years ago made this point tellingly (Morris et al 1953). But bus drivers are not the only jobs that require sedentary postures for long periods. A recent publication has reported on the effects of sitting occupation on the health of over 10,000 men and women in English and Scotland. Over a 12-year period, 754 deaths were reported, and analysis showed that, compared to those in standing or walking occupations, there was a higher risk of mortality from all causes and from cancer for women in sitting occupations, for example [47].

Too many city workers spend the day in largely indoor sedentary occupations [41], unlike their active hunter-gatherer predecessors. Employers as well as employees have a vested interest in increasing activity levels in the work place, and this can be done in a variety of ways. Much attention has been given to making more use of the stairs rather than the elevator or escalator, for example (Webb & Eves 2006; Webb & Eves 2007, 114-119). The very design of the building has a major part to play here: in many offices, the lift shaft is centrally-placed in the foyer, in clear sight of the front door, while the stairwell is tucked away to one side. In an evolutionary-concordant office, a grand staircase would occupy pride of place in the foyer, with light-filled landings replete with seating, artwork and plants. The low-fat office would also develop less sedentary working practices [48] and have cycle racks and showers so as to further encourage active travel.

A similar approach can be taken with the design of schools, in the size and format of classrooms, the relationship of the indoor to the outdoor space, the length of lessons, facilities for physical activities and the amount of time per day spent being "sufficiently active". It has been shown for example that classroom design can have a very significant impact on the learning rates of primary school pupils, based on a study of classrooms in seven different UK schools [35]. Windows and our connection with the outside world are also crucial. A seminal study in a hospital showed that the time patients needed for recovery was reduced by up to 8.5% if they were in rooms with windows affording a suitably therapeutic green view [49], while research in a Korean hospital showed that patients recuperating in wards with windows orientated to the sunny southeast recovered faster than those in rooms looking to the more shady northwest [50]. Effective building design therefore needs to consider many aspects of our palaeolithic genome.

Social Issues

Although there is not space to discuss it in any detail here, there has also been study of the hunter-gatherer mindset, with a consideration of the psychological aspects underpinning tribal societies and hunting groups. These issues still resonate today in our large poly-tribal conurbations and impact on issues such as the concepts of "community" and consequently on aspects of the town planning of "neighbourhoods". In addition, some forms of criminal activity, especially the urban gang (a proxy for hunting groups), might also be addressed through, for example, team sport. This can provide a positive, evolutionary-concordant approach to such anti-social behaviour [51], but to be effective, adequate sports facilities need to be factored into the urban landscape.

Conclusion

Our consideration of town-planning from a human evolutionary perspective therefore takes a wide overview. Evolutionary-concordant health behaviours need to be identified and encouraged at all levels, personal and institutional, and subsequently through policy and practice. The approaches needs to be embedded in and adopted by the "Healthy Cities" movement [1], promoted through the new local Health and Wellbeing Boards (Health and Social Care Act 2012), through national Public Health programmes, through legislation (such as the proposed Nature and Wellbeing Act) as well as through better town planning and active building designs.

Tomorrow's cities and urban societies would be healthier if configured or reconfigured on evolutionary-concordant principles, working with our palaeolithic genome rather than against it. The challenge is both real and imminent, for urbanisation is increasing globally at an unprecedented pace. The human race has adapted to living in forests, valleys, deserts, jungles, mountains and open plains. But can it take the next step in its evolutionary progress, and adapt more successfully to such an extensive urbanised environment of its own making? To open this crucial debate, the studies discussed in this paper, and expanded on elsewhere [25,52] suggests co-ordinated approaches to an evolutionary-concordant urban future. Towns may not be our natural habitat, but we can make them our optimal one [53-57].

References

1. Rydin Y, Bleahu A, Davies M, Groce N, Scott I, et al. (2012) Shaping Cities for Health: complexity and the planing of urban environments in the 21st century. The Lancet published online 30th May 2012.
2. Stringer C, Andrews P (2011) The Complete Word of Human Evolution. London: Thames & Hudson 236-239.
3. Milne G (2017) Uncivilised Genes: human evolution and the urban paradox, Crown House Publishing Ltd
4. Marmot M, Wilkinson R (ed.) 2006 Social Determinants of Health (2nd ed) Oxford: Oxford University Press.
5. Ridsdale R, Gallop A (2010) Mortality by cause of death and by socio-economic and demographic stratification 2010.
6. Lindeberg S (2010) Food and western disease: health and nutrition from an evolutionary perspective. London: Wiley-Blackwell.
7. Brenna Hassett (2017) Built on Bones: 15,000 Years of Urban Life and Death. *Science* 356: 811. [crossref]
8. Roberts C, Cox M (2002) Health and Disease in Britain from Prehistory to Present Day, Sutton Publishing
9. Price W (1938) Nutrition and Physical Degeneration: a comparison of the primitive and modern diet and their effects.
10. Zweiniger-Bargielowska, I 2000 Austerity in Britain: Rationing, Controls and Consumption, 1939-1955. Oxford University Press
11. Voegtlin W 1975 The Stone Age Diet.
12. Cordain L, Gotshall R, Eaton SB (1998) Physical Activity, energy expenditure and fitness: an evolutionary perspective. *Int J Sports Med* 19: 328-335.
13. Eaton SB, Konner M, Shostak M (1988) Stone agers in the fast lane: chronic degenerative diseases in evolutionary perspective. *Am J Med* 84: 739-749. [crossref]
14. Konner M, Eaton SB (2010) Paleolithic nutrition: twenty-five years later. *Nutr Clin Pract* 25: 594-602. [crossref]
15. Lindeberg S, Lundh B 1993 Apparent absence of stroke and ischaemic heart disease in a traditional Melanesian population: a clinical study in Kitava. *J. International Medicine* 233: 269-275.
16. White MP, Alcock I, Wheeler B, Depledge M (2013) Would you be happier living in a greener urban area? A fixed-effects analysis of panel data. *Psychol Sci* 24: 920-928.
17. Brothwell, D and Brothwell, P (1998) Food in Antiquity: A Survey of the Diet of Early Peoples. Baltimore: John Hopkins University Press.
18. Stanford C, Bunn H (ed.) 2001 Meat-Eating and Human Evolution. Oxford: Human Evolution Series, Oxford University Press.
19. Ungar P (ed.) 2006 Evolution of the Human Diet. Oxford: Oxford University Press.
20. Cohen M (2012) History, Diet and Huntergatherers. In K. Kiple & C. Kriemhild (eds): 63-71.
21. Kiple K, Kriemhild C (eds) 2012 The Cambridge World History of Food. Cambridge: Cambridge University Press.
22. Wing, ES 2012 Animals Used for Food in the past as seen by their remains excavated from archaeological sites. In K Kiple and C Kriemhild (ed.): 51-58.
23. Oyebode O, Gordon-Dseagu V, Walker A, Mindell J (2014) Fruit and vegetable consumption and all-cause, cancer and CVD mortality: analysis of Health Survey for England data. *J Epidemiol Community Health*.
24. Esliger D, Trembaly M, Copeland J, Barnes J, Huntingdon, et al. (2010) Physical Activity profile of Old Order Amish, Mennonite and contemporary children. *Medicine & Science in Sports* 42: 296-303.
25. Marshall S, Milne G, Rook G, Tinnerman R (2015) 'Walking: a step-change towards healthy cities'. *Town and Country Planning Journal* 125-129.
26. O'Keefe J, Cordain, L 2004 Cardiovasular Disease resulting from a diet and lifestyle at odds with our Palaeolithic Genome: how to become a 21st-century Hunter-Gatherer. *Mayo Clin Proc* 79: 101-108.
27. O'Keefe J, Vogel R, Lavi C, Cordain L (2011) Exercise like a Hunter-Gatherer: a prescription for Organic Physical Fitness. *Progress in Cardiovascular Diseases* 53: 471-479.
28. Lieberman DE, Venkadesan M, Werbel WA, Daoud AI, D'Andrea S, et al. (2010) Foot strike patterns and collision forces in habitually barefoot versus shod runners. *Nature* 463: 531-535. [crossref]
29. Sundquist K, Frank G, Sundquist J (2004) Urbanisation and incidence of psychosis and depression: follow-up study of 4.4 million women and men in Sweden. *Br J Psychiatry* 184: 293-298. [crossref]
30. Maas J, Verheij RA, de Vries S, Spreeuwenberg P, Schellevis FG, et al. (2009) Morbidity is related to a green living environment. *J Epidemiol Community Health* 63: 967-973. [crossref]
31. Mitchell R, Popham F (2008) Effect of exposure to natural environment on health inequalities: an observational population study. *The Lancet* 372: 1655-1660.
32. Rook GA (2012) Hygiene hypothesis and autoimmune diseases. *Clin Rev Allergy Immunol* 42: 5-15. [crossref]
33. Rook G, Raison C, Lowry C (2014) Microbial "Old Friends", immuno-regulation and socio-economic status. *Clinical & Experimental Immunology*.
34. von Mutius E, Vercelli D (2010) Farm living: effects on childhood asthma and allergy. *Nat Rev Immunol* 10: 861-868. [crossref]
35. Barrett, P, Zhang, Y and Kobbacy, K (2013) A holistic, multi-level analysis identifying the impact of classroom design on pupil's learning. *Building and Environment* 59: 678-689.
36. Rook G, Raison C, Lowry C (2013) Childhood microbial experience, immunoregulation, inflammation and adult susceptibility to psychosocial stressors and depression in rich and poor countries. *Evol Med Public Health* 1: 14-17.
37. WHO 2012 IARC Diesel Engine Exhaust Carcinogenic: press release no. 213 (2012). World Health Organisation
38. TfL (k) Improving the Health of Londoners: Transport Action Plan. London: Transport for London.
39. TfL RTF (2013) Roads Task Force Technical Note 21. London: Transport for London.
40. NICE (2008a) Public Health Guidance 8: Physical Activity and the Environment. London: National Institute of Clinical Excellence.
41. NICE (2008b) Public Health Guidance13: Promoting Physical Activity in the Work Place. London: National Institute of Clinical Excellence.
42. NICE (2009) Public Health Guidance 17: Promoting Physical Activity for Children and Young People. London: National Institute of Clinical Excellence.
43. NICE (2010) Public Health Guidance 25: Prevention of cardiovascular disease. London: National Institute of Clinical Excellence.
44. NICE (2012) Public Health Guidance 41: Walking and Cycling: local measures to promote walking and cycling as forms of travel or recreation London: National Institute of Clinical Excellence.
45. PHE and LGA (2013) Obesity and the Environment: increasing physical activity and active travel. Public Health England & Local Govt Association.
46. Martin A, Goryakin Y, Suhrcke M (2014) Does active commuting improve psychological wellbeing? Longitudinal evidence from eighteen waves of the British Household Panel Survey Preventive Medicine 69: 296–303.
47. Stamatakis E, Chau J, Pedisic Z, Bauman A, Macniven, R, et al. (2013) 'Are sitting occupations associated with increased all-cause mortality, cancer and cardiovascular disease mortality risk?' *PLOS ONE* 8 e73753: 1-10.
48. Smith L, Ucci M, Marmot A, Spinney R, Laskowski M, et al. (2013) 'Active Buildings: modelling physical activity and movement in office buildings- an observational study protocol. *BMJ Open* 3: e004103.
49. Ulrich R (1984) View through a window may influence recovery from surgery. Science, New Series 224, iss 4647: 420-421. American Assoc Adv Science.
50. Choi J, Beltran L, Kim H (2011) Impacts of indoor daylight environments on patient average length of stay in a healthcare facility. *Building & Environment* 50: 65-75.
51. Hartmann D, Depro B (2006) Rethinking Sports-based Community Crime Prevention: a preliminary analysis of the relationship between Midnight Basketball and Urban Crime Rates. *Journal of Sport and Social Issues* 30: 180-196.

52. Milne G (2015) 'The Evolutionary Determinants of Health Programme: urban living in the 21st century from a human evolutionary perspective'. *Archaeology International* 18: 84-96.

53. Cordain L (2012) The Paleo Diet: Lose Weight and Get Healthy by Eating the Food You Were Designed to Eat. New York.

54. HMG 1999 Daylighting in Schools: an investigation into the relationship between Daylighting and human performance. Heschong Mahone Group.

55. Hu FB, Willett WC (2002) Optimal diets for prevention of coronary heart disease. *JAMA* 288: 2569-2578. [crossref]

56. Klein M (1995) The American Street Gang: its nature, prevalence and control.

57. Klein M, Kerner H, Maxson C, Weitekamp E (2001) The eurogang paradox: Street gangs and youth groups in the US and Europe.