# BIOSOCIAL WORLDS

## ANTHROPOLOGY OF HEALTH ENVIRONMENTS BEYOND DETERMINISM

EDITED BY
JENS SEEBERG
ANDREAS ROEPSTORFF
LOTTE MEINERT

CULTURE + HEALTH

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# Biosocial Worlds

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# Biosocial Worlds

*Anthropology of health environments beyond determinism*

Edited by Jens Seeberg, Andreas Roepstorff and Lotte Meinert

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# Introduction

Jens Seeberg, Andreas Roepstorff and Lotte Meinert

Anthropological explorations of the worlds we live in have systematically destabilised the boundary between nature and culture that once served as a founding dichotomy of anthropology as a discipline. Not only has the idea of nature as a domain that can exist outside the reach of the impact of (human) culture been challenged by the massive impact of humanity on the global ecosystem, as reflected in the labelling of our current geological epoch as the Anthropocene, it has also become increasingly clear that the ability to *produce* culture is not an exclusively human capacity. Indeed, the anthropological concept of culture can no longer ignore 'cultivation practices in non-human cultures, such as ants, that go back hundreds of millions of years' (Lien et al. 2018, 16). Furthermore, as Palsson has pointed out, life itself has become unstable in a range of ways (Palsson 2016). Body parts and organs are augmented or replaced with implants. Organs travel from one body to the next and from one species to another. The renewed importance of the field of epigenetics, as well as the unfolding exploration of the human microbiome, increasingly unsettles old constructs of the individual, highlighting permeability and relationality between organisms and between organism and environment. These and related developments in our understanding and production of life have led to a suggestion to replace the notion of 'human being' with one of 'human becoming' (Ingold 2013).

Such changes and insights call for a repositioning of anthropology *vis-à-vis* biology, as they seem to open new possibilities for both disciplines. *Biodeterminism* – the assumption that life is genetically predetermined or inscribed – no longer upholds the status of dominant scientific paradigm among biologists. Keller, for example, has pointed to the long history of the nature–nurture debate and its refusal to die (Keller 2010). Yet the debate thrives from the continuous production of new data in one camp that ought to convince members of the other camp, and she argues

that semantic difficulties have contributed significantly to driving the disagreement. Importantly, Keller points to the mirage of a space between nature and nurture and, tracing the expression back to Galton, asserts that attempting to replace *genetic determinism* on the one hand with a similarly reductionist opposite of *social determinism* on the other would lead nowhere (Keller 2010). However, as noted by Lewontin and many others, some very real effects emerged from this 'mirage of a space': the separation of the natural and the social had opened the space in which deterministic 'projections' could be cast in both directions between the two, each constituting a Platonic screen for the other (Lewontin 1993). Latour pointed out this model in his critique of the social sciences, highlighting the projection of the social onto the natural (Latour 1993), but, we argue, the reverse projection is equally problematic.

Thus, this volume brings together state-of-the-art contributions to critical anthropological thought around the social and biological as well as ethnographic explorations of human and non-human life in the light of changing understandings of biology.

## Projection

We shall use two short stories by author Hans Christian Andersen (1805–1875) – a contemporary of Charles Darwin (1809–1882) – to illustrate what we mean by *projections of determinism* in the space created by the separation of the social and the biological.

In the well-known fairy tale of 'The Ugly Duckling' (1846), after the hatching of a brood of beautiful ducklings, a bigger egg takes longer to develop than the others. When the bird finally comes out of the egg, its large size makes it appear ugly and deformed in the eyes of the others. Initially suspected of being a turkey, the young bird, however, proves to be a good swimmer, thus passing as a duckling. However, its size, shape and behaviour make it the target of constant ridicule and rejection, leading the youngster to run away. Having miraculously survived a long and lonely winter, the 'ugly duckling' happens upon three beautiful swans on a fine spring day. As it approaches them with little expectation for a warm welcome, it sees its own reflection in the water, now 'a graceful and beautiful swan'. Andersen's well-known moral of the story, 'to be born in a duck's nest, in a farmyard, is of no consequence to a bird, if it is hatched from a swan's egg' (Andersen 1846), when understood as the allegory of human life so patiently explained by countless parents

to their children, projects the biological onto the social. The story was a key to Andersen's international breakthrough and has been widely read and made into films and theatre plays. Like all good literature, it allows for varying interpretations, focusing, for example, on parallels with Andersen's own life (Andersen 2003), or the pain of genealogical bewilderment in children with substitute parents (Sants 1964). Across them, it certainly places innate qualities over environmental influences in the understanding of life: predetermined *human being* rather than *human becoming*, to paraphrase Ingold (2013). Despite social influences, the 'true' biological being will unfold at some point. The appeal of the story has made it a useful metaphor in a range of scientific contexts, including for the redemption of sympatric speciation as an organising principle in evolutionary biology (Via 2001).

In contrast, in a less well-known story by Andersen, 'The Drop of Water' (1847), the author illustrates the projection of the social onto nature. Since it is less known, we shall quote it at some length. The tale tells of the marvels of the magnifying glass 'that makes everything a hundred times larger than it really is'. When looking at a drop of water through it, Creep-and-Crawl, an old man 'who would always make the best out of everything', sees a ferocious fight among human-like microorganisms. He magically colours them with a drop of witch blood to make them now appear like 'naked savages' and calls the other protagonist of the story, a nameless wizard.

> The wizard who had no name looked through the magnifying glass. It actually appeared like a whole town, where all the inhabitants ran about without clothes! it was terrible, but still more terrible to see how the one knocked and pushed the other, bit each other, and drew one another about. What was undermost should be topmost, and what was topmost should be undermost!–See there, now! his leg is longer than mine!–whip it off, and away with it! There is one that has a little lump behind the ear, a little innocent lump, but it pains him, and so it shall pain him still more! And they pecked at it, and they dragged him about, and they ate him, and all on account of the little lump. There sat one as still as a little maid, who only wished for peace and quietness, but she must be brought out, and they dragged her, and they pulled her, and they devoured her!
>
> 'It is quite amusing!' said the wizard.
>
> 'Yes; but what do you think it is?' asked Creep-and-Crawl. 'Can you find it out?'

> 'It is very easy to see,' said the other. 'It is some great city, they all resemble each other. A great city it is, that's sure!' (Andersen 1847, 23–4)

The story first appeared in a collection sent to Charles Dickens in gratitude of his hospitality during Andersen's first visit to London. Andersen took a romantic rather than a revolutionary position. Still, he was abhorred by the brutality of urban poverty at the height of industrialisation, described in Dickens' works and echoing some of Andersen's own early life experiences. To Andersen, the big city epitomised a primitive cruelty found in nature and in 'naked savages' as they had been described and construed in colonial Europe.

Invoking Andersen's two stories allows us to argue that projections in the space between the biological and the social cannot be reduced to discussions of theory-building in biology and the social sciences. Rather, they constitute pervasive imaginations that transcend understandings of health and the body that have travelled across generations and societies. Similarly, the projections of thinkers like Darwin and Spencer may be recast as efforts to systematise ideas that were common in vaguer versions in contemporary societies.

The projection of principles of competition based on a capitalist world order onto natural evolution in Darwinism (Lewontin 1993) was followed by a projection back onto the social ordering of societies and civilisations based on the logic of 'survival of the fittest' of social Darwinism. Whereas these classical contributions to secular understandings of evolution have been softened since their original appearance, their neo-Darwinian incarnations are fiercely protected, as shown by Lewontin in his critique of doctrines of sociobiology (Lewontin 1993). Ingold shows how this neo-Darwinian defence work maintains the duality of the natural and the social, enabling projections between the two (Ingold 2013). Such projections carry a directional causality, and so constitute powerful means to establish discursive authority. Perhaps paradoxically, even if we argue for the de-separation of the biological and the social, it remains important to unfold the consequences of their discursive separation.

Many of the contributions in this volume point us to a gap between the two, and analyse what may be seen as projections. The works of the contributing authors open new ways to think about the biosocial in anthropology, either by way of anthropological reflection or through ethnographic case studies. Focusing primarily on the projection of the biological onto the social, the chapters point to some of the very real impacts of this duality, while also creating stepping stones for further

contemplation on how to develop analytical lenses that serve to de-separate the biological and the social. For example, Livingston's chapter provides a critique of the projection of singular disease categories onto complex situations of co-morbidity, while the chapter of Meinert and Whyte explores how categories of trauma or spirits may project different 'plans of action', with adjacent ideas about biology and sociality, for dealing with legacies of violence. Petryna's chapter shows the projection of the end of the world onto the screen of climate change, behind whose horizon 'blindsidedness' reigns. Other chapters explore how neonatal babies are projected onto piglets (Svendsen), or the brain onto the gut (Young), or the social onto the body (Lock; Napier). While they point to the workings of projections, they also combine to show new analytical potentials to narrow and eventually close the gap between the biological and the social.

## Health environment

For several decades, up to the completion of the Human Genome project in 2003, the nature–nurture debate that had been central to early American anthropology seemed to have tilted to the advantage of the 'nature' position, leaving only a limited space for critical dialogue. The Human Genome project was celebrated as 'nature's complete genetic blueprint for building a human being' (National Human Genome Research Institute 2015). Perhaps paradoxically, this achievement contributed to a realisation that the implied genetic predetermination of human lives and human behaviour was vastly exaggerated within the Darwinian paradigm. This led to the return of the field of epigenetics that explores the interaction between environment and activation or deactivation of genetic dispositions that influence the individual human life – and potentially the lives of subsequent generations (see Lock, this volume; Napier, this volume). Such new understanding of the malleability of human biology potentially undermines the century-long insistence within the fields of medicine and epidemiology on the *universality* of human biology. It calls, instead, for an understanding of local biologies, as first proposed by Lock, implying that 'differing accounts about biological ageing are not simply the result of culturally shaped interpretations of a universal physical experience but the products […] of an ongoing dialectic between biology and culture in which both are contingent' (Lock 1993, xxi).

At first glance, it seems as if the move from genetics to epigenetics should signal a drive to understand the role of the environment in the

development of an organism, whether human or non-human. However, as pointed out by both Lock and Niewöhner (this volume), the epigenetic framework remains predominantly a *genetic* perspective. Although the environment enters into the genetic, co-determining what is being expressed and how the organism is shaped, it does so via a molecular mechanism, for example, as the phosphorylation of DNA or modification of histone complexes. Seen from within this framework, the environment ultimately becomes molecularised, that is, the environment exists to the extent that it can be traced as a variable that shapes a particular molecular configuration, and hence changes the properties of the genome.

Radicalising this claim, one may argue that epigenetics teaches us something new and valuable about genetics, but it is difficult to see how it could scale up to be the *general* story of how organisms and environments interact. Instead, Niewöhner argues, we should go beyond both a 'gene-centric' and an 'environment-centric' approach to identify the particular practices that dynamically shape *both* environments and genes. Such an approach may trace its pedigree from a long lineage focusing on 'natural history', and may ultimately be Aristotelian in the focus on habits (Atran 1993). It argues for a *customary biology* (Niewöhner 2011), that is, a biology which shifts the analytical focus away from genes *and* environment to how customs, or patterned practices (Roepstorff et al. 2010), may shape environment *and* genome. In this understanding, the notions of 'health' and 'environment' are entangled in a way that moves their relation beyond interdependence to one of inseparability. The subtitle of this volume captures this insight through the concept of 'health environment'.

'Health environment' may, we believe, allow for a fresh analytical perspective on Lock's notion of local biology. This is beautifully illustrated in Svendsen's analysis (this volume) of pigs as experimental model animals in a Danish context. Already, the ordinary Danish pig, 'with leaner meat, an extra rib and large litters', is an instance of a local biology, which is currently being exported to the rest of the world. The Danish pigs are the result of highly specific practices of breeding based on systematic selection. Underlying mechanisms, most likely not only – if at all – epigenetic, shape the genetic makeup of the pig, and go hand in hand with a specific environment in which the pigs are reared. The general case of the local biology of the Danish pig is taken a step further in the laboratory practices Svendsen studies. Here, the local biology of immature piglets born prematurely by Caesarian section become models of weak infants at risk of potentially devastating inflammation of the gut, thus ideally improving the health of preterm human infants worldwide. Paraphrasing Willerslev, it is the piglet's status as non-human on the one

hand that makes it ethically justifiable to force early birth on the piglets and ultimately kill them, while their existence as *non* non-humans on the other is the rationale for making them model animals in the first place, so comparable to infants that findings may be generalised from one species to the other (Willerslev 2004).

While this case certainly involves genes and environments in very specific and dynamic configurations, the engine infusing energy into these interactions can be found neither at the level of genes nor of environment. Rather, it is embedded in very particular networks and institutions of power, interest and intentions. Failing to take these into account means failing to identify critical factors shaping both environment and genes.

## Scale

The discussion about how to define and delineate the environment also involves questions of scale. Following Niewöhner's concept of the *embedded body* (Niewöhner 2011), Lock points out that an *epigenetic world* (as perceived from an anthropological perspective) is one where 'recognition of intergenerational continuities other than by the transmission of DNA brings about a crucial ontological shift; an embedded body is not the product of interactions of nature and nurture but, by definition, is situated in an entanglement of nature–nurture that transcends generations, raising profound questions about concepts of self and body as clearly bounded entities' (Lock 2013, 303). Such permeability of bodies, which had previously been seen as bounded entities, contributes further to undermining the traditional 'division of labour' between anthropology and biology. Opening disciplinary boundaries allows us to move beyond the problem of bounded environments to a discussion of scale as a central question of analysis – a need that has appeared in other debates as well, for example, in the context of globalising dynamics (for instance, Collier and Ong 2005; Tsing 2015) and in global health (Adams 2016).

In the context of the present volume, this move can be seen as requiring an extension of anthropology to include reflections on the social life of the bacterial cells living in or on the human body seen as a *holobiont* (Young, this volume). Young uses the study of the human biome to move us beyond the positions of determinism versus free will as he discusses how bacteria take decisions to create (or not) biofilm, or to send out (or not) into the universe themselves as they are transformed into spores (sporulation) that may eventually mature into biofilm elsewhere. While it is still little understood how gut bacteria communicate bi-directionally with the brain, and

what effects this may have on human decision-making processes, moods and behaviours – if, indeed, these should not just be seen as integral – Young points out that bacterial decision making is itself not predetermined. Rather, we should understand quorum-sensing of bacteria as a capacity for stochastic intelligence: 'During periods of collective stress, such as exposure to antibiotics, a small fraction of individuals become "competent", able to take up DNA from the environment. Competence is a stochastic function (the result of randomness in transcription) that enables the leader to exploit noise (random variation) generated during quorum-sensing' (Young, this volume). Scale works at two levels here. One is the qualitative shift incurred by the sheer number of micro organisms, leading to increasing differentiation among them and involving individual decision making; and the other is the shift of analytical scale, relating the behaviour of people accessible to standard ethnographic methods to the behaviour of bacteria in the gut, seen through the lens of (an anthropological reading of) microbiology.

Scale is also important in the analysis of development of multi drug-resistant tuberculosis (MDRTB) by Seeberg (this volume). He compares the stress experienced by Mycobacterium tuberculosis (M. TB) when exposed to anti-tuberculosis medicines to that resulting from attacks by mycobacteriophages, viruses that target tuberculosis (TB) bacteria. The outcome of both kinds of engagement is unpredictable and may be either beneficial or detrimental for the TB bacteria, depending on events at other scales of reality. These include, for example, the life conditions of the host and his or her interaction with family and healthcare providers; the constitution of the healthcare system providing treatment; and decisions of global actors like the Bill and Melinda Gates Foundation to fund technological solutions to be rolled out in contexts that favour budget cuts in government-funded healthcare in low-income countries where TB is rampant. In theory, the combination therapy that has been used for decades should make the development of drug resistance impossible. However, the configuration of actors at very different scales seems to create a situation where M. TB is able to engage with anti-TB drugs in ways similar to its engagements with mycobacteriophages.

The many glitches in drug delivery and global policy priorities create ample opportunity for TB bacteria to make use of their stochastic intelligence. Indeed, even if the intention is to kill them, drug-resistant bacteria may *de facto* be considered to be domesticated versions of treatable TB, created as they are by human intervention. Hence, one could apply Napier's phrase: '… human selection for tameness is not "natural selection"; it is "human selection" – a social process about creating social

environments in which certain genetic traits emerge. As such, it has quite a bit to do with evolution, but as much, or more, with the effects of social environments – including experimental settings – on genetics' (Napier, this volume). Only, Napier is talking about multi-species interaction at a different scale, namely of domestication through selective breeding of foxes that become dog-like after only a few generations, and subsequently remain 'dogs'. Napier shows here that social exposure is the key variable that allows genes to function or be shut off. He goes on to discuss another 'social disease', namely that of diabetes, where such biosocial dynamics have been largely ignored, globally leading to an over-reliance on biomedical and technical explanations and interventions that are too expensive to access for most people in most countries, while largely ignoring the social dynamics that drive diabetes in individual bodies on a global scale.

The critique of neo-Darwinian evolution that informs many of the contributions in this volume points to the centrality of the discussion of temporal scales with its embedded issues of ontogenesis and phylogenesis. Even if nature–nurture can now be de-separated, and bacteria and brain inform each other's decisions through biosocial processes, scales of time become further complicated by the attempts to bridge such different scales of sociality. The return of epigenetics may imply an 'evolution on speed' in the sense that genetic changes may take effect much faster than previously assumed. If a conducive health environment exists, such change happens at the speed of generational turnover for a given kind of organism. In humans, it seems to happen at a pace (accentuated by the size of the population) that increasingly translates so-called non-communicable conditions and 'lifestyle diseases' into epidemics (Seeberg and Meinert 2015).

At the level of bacteria, change in the form of mutation happens at the speed of cell division, and decision making as described by Young may take place in the course of hours. Temporality is complicated by the interaction of organisms with different timescales, as in the case of M. TB. TB cases with drug-resistant strains constituted a negligible population a few decades ago, whereas the impact of the current failure to control TB may result in children and grandchildren of today's TB patients attracting incurable strains of TB in coming decades. The temporal scales of different organisms are out of sync, so to speak, and the natural limitations of humans to act outside the scope of their own temporal horizon poses challenges to interdisciplinary ambitions.

Petryna (this volume) addresses this issue in her discussion of the human capacity, including that of scientists, to understand ecosystemic transformation in the context of global climate change. Here, both spatial

and temporal scales are maximised, and yet the human capacity to predict – with whatever degree of uncertainty – the future impact of current man-made emissions into the global ecosystem is, by and large subject to arbitrary timeframes – and is furthermore characterised by the inability to understand sudden non-linear changes that may be either catastrophic tipping points or trigger points for remedial action. While such sudden changes may be observed relatively easily (thanks to technological intermediaries) at the microscopic level (because they happen rapidly when perceived through a human scale of time), the reverse is true for the perceived slow development of global change.

Behind folds of the changing horizon loom landscapes hidden by 'blindsidedness', Petryna points out, as she invokes Fabian's classic work on coevalness. However, where Fabian criticised evolutionism in the social sciences for placing contemporary populations at different temporal levels (Fabian 1983), Petryna points us to a parallel *temporal-teleological* displacement in the relationship between science and nature, most clearly exemplified by Darwinism with its teleological assumption that adaptation necessarily prevails.

## Synergies

How do conventional ways of classifying disease establish barriers to understanding the biosocial complexities that frame the workings of both disease and treatment? In her chapter on co-morbidity in Botswana, Livingston points out that biology is often assumed to be a main determinant of singular illnesses, but in situations of multiple sickness biology often points in many directions simultaneously: co-morbidities may be clearly intertwined with social, political and health systemic factors, which themselves interact at biological levels. The complex co-morbidity of TB, HIV/AIDS, and cancer can be seen as a biosocial synergy that plays itself out not only at the levels of social distribution and epidemiology of disease. It also shapes processes at the clinical level, when patients seek diagnosis and treatment in health systems whose institutional infrastructure is designed to separate disease categories into, for example, TB, HIV, or cancer. Yet, in the bodies and lives of patients these disease categories are intertwined, and this kind of synergy challenges our analytical categories and calls for reconceptualisation. Ontological certainties that distinguish one disease from the other are questioned, and how the diseases interact with each other and with social and other factors is foregrounded. Livingston gives the example of one form of cancer, Kaposi's

sarcoma, which practically does not exist in women unless they are HIV positive. So, are Kaposi's sarcoma and HIV two diseases or one? Such matters of definition continue to be highly impacted by political, economic, moral and institutional projects that arise around specific diseases.

Whether diseases and epidemics are defined as single or multiple entities may be quite significant in cases where such definition comes to determine how health problems are addressed. If cancer is seen as intimately intertwined with and part of the HIV epidemic, this may have consequences for how funding is spent, how prevention and treatment is organised, and how patients are met in clinical contexts.

Co-morbidity, at the scale of epidemics, has been conceptualised as *syndemic* in response to the dominant biomedical conception of diseases as distinct entities in nature, located in specific organs, separate from other diseases and independent of the social and cultural contexts in which they are found (Singer 2009, 25). The syndemic perspective allows us to think about disease in relational rather than categorical terms, and to consider the importance of interacting social (and environmental) conditions that promote the spread of disease. In syndemics, the health effects of co-morbid conditions are not additive, but multiplicative (Singer 2009, 26).

Synergies are further explored in Meinert and Whyte's description of the rapid spread of trauma and spirits in Northern Uganda after the civil war. The number of local healers dealing with spirit possessions grew significantly alongside an influx of NGOs and humanitarian organisations treating PTSD. The authors suggest analysing the spread as related syndemic processes of situated and concerned responses to violence, which involve local biosocial worlds, as well as humanitarian psychology. Pointing out that the behavioural symptoms of both spirits and trauma often co-exist with other problems such as alcoholism, HIV and diverse health conditions, the authors discuss how these problems are intimately intertwined, making the separation of the biological and the social untenable.

In biomedical discourse, PTSD, alcoholism and HIV are commonly described as forms of co-morbidity. Yet when these problems tend to come in the same clusters repeatedly, it should make us ask questions about the categories that make them *appear* as separate conditions. From a broader perspective, trauma and related problems thrive in particular social, economic and historical conditions, and their rapid spread may, indeed, be seen as syndemic (Singer 2009; Singer and Clair 2003) at the population level. Where a biomedical perspective on PTSD foregrounds the damage to the individual (biological) brain during traumatic events and regards other factors (such as alcoholism) merely as 'triggers' or consequences of disease, a syndemic perspective enables a synergetic view

of biosocial interaction, which does not reduce or range factors and consequences as biological or social. This perspective on biosocial becoming involving many different kinds and levels of influences obviously has consequences for how health problems related to legacies of violence are dealt with.

## Beyond determinism

Biosocial worlds, therefore, are created in the engagement with the human condition more broadly, as described in this volume, and they are co-created by these descriptions, either as propositions or as critiques. Building on Lock (this volume), we have suggested that the tendency in biology to downscale the environment to something that is experimentally practical is a threat to the understanding of biosocial dynamics. Here, biology may learn from anthropology.

However, this raises the problem of scale and how to work across very different *scales of experience*. In their common forms of knowledge production, biology has access to knowledge at scales that are usually inaccessible to anthropology, whereas anthropology has access to theoretical understanding of social complexities that are inaccessible to biology. This anthropological contribution points to the need for developing an analytics of biosocial complexity that may very well come at the cost of some of the taxonomical neatness that has been a founding principle of biology, and therefore of biomedicine.

How is it possible to pursue this agenda in shared spaces of exploration and interdisciplinary dialogue between anthropology, biology and medicine? Many cases presented in this volume indicate – and critically challenge – such spaces, whether they be laboratories or clinical spaces (Svendsen; Niewöhner; Livingston); biosocial spaces where the microscopic may be integrated in anthropological analysis (Young; Seeberg); or the broader exploration of the effects of tensions between biologically grounded categories and biosocial complexities (Lock; Napier; Meinert and Whyte; Petryna).

Clearly, the degree of proximity matters. The closer the collaboration, the greater the need for scientists to find mutually agreeable entry points for interdisciplinary dialogue and exploration. We suggest that the focus on scale may be a useful entry point, not for a backward-looking re-enactment of disciplinary boundaries within neatly carved 'scalar' principles, but as a point of fruitful exploration of such boundaries with the intention of challenging and reshaping them, accepting that scale and

scalability are also political and moral spaces, and that the 'non-scalable' (Tsing 2015) should not be lost from analysis.

Doing so may open spaces for the larger issues of complex synergies between biosocial entities otherwise too often conceptualised as distinct, as well as the definition of environment, which in anthropology is closely related to the fluid engagement with the concept of context. Our book requires a move beyond the Darwinist luggage of adaptive evolution that has provided not only the core of biological determinism up to its human genomic climax, but has also spilled over into many other domains, as shown in this volume.

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# Chapter 1
# Permeable Bodies and Environmental Delineation

Margaret Lock

> The 'control of nature' is a phrase conceived in arrogance, born of the Neanderthal age of biology and philosophy, when it was supposed that nature exists for the convenience of man. (Carson 1962, 197)

## Traumatised environments

A group of experts speaking at an International Geological Congress in late August 2016 declared that the geological epoch known as the Holocene through which humans have lived during the past 11,000 years and longer has been eclipsed. We are now living in the Anthropocene, an era characterised by cumulative destructive human activity on earth itself, much of it seemingly irreversible. The historian Dipesh Chakrabarty highlights the peculiarity of this new epoch: 'the Anthropocene spells the collapse of the Kantian distinction between natural history and human history' (Chakrabarty 2009). He bases this assertion on abundant evidence that, in contrast to previous epochs, humans are the primary force transforming the globe today, with enormous effects on human health and wellbeing. Conferences about the Anthropocene started to take place long before its formal declaration, and between 2013 and 2015, 27 had already occurred.

Numerous mineral compounds, including more than 500 million metric tonnes of pure aluminium, have been manufactured since the Second World War, much of which has sedimented into earth's layers. Even more striking are 'mineraloids' – glass and plastics – 300 million tonnes of which are made annually and are present everywhere on the earth's crust and in all

the oceans. As each couple of minutes pass, Coca-Cola produces 9,000 new plastic bottles. Concrete, a rock of our own making, encases much of the globe. Our chemical footprint has accumulated worldwide as toxic waste, principally in the form of $CO_2$, nitrogen fertilizer, pesticides, and diesel fuel.

Environment – nature – is exhibiting all the signs of stress, trauma, toxicity and abuse usually associated with suffering human bodies – the 'ruins of capitalism', as Anna Tsing puts it, are all too evident in vast swaths of the globe (Tsing 2015). But geologists need hard evidence of an *irreversible* transition in order to identify a new epoch. Their decisions are pegged to a so-called 'golden spike' – a marker that appears in ice-cores, the oceans, lake sediments, and soils, where recognisable fossilised strata appear that can be hammered, sampled, and/or dug up. Such changes are known as a 'time-rock unit'. Following much debate, the International Union of Geological Sciences agreed that July 1945 constituted such a spike – the day when the first nuclear device was exploded, leaving rare isotopes of plutonium distributed all over the globe, including Antarctica and Greenland (Biello 2015).

For more than a decade we have been living with another fundamental change known as the 'post-genomic' era. The human genome is no longer recognised unequivocally as the driving force of life, but rather as 'reactive' to environments external and internal to the body (Gilbert 2003). In other words, the very 'nature' of what it is to be human has been revised on the basis of knowledge, largely brought to light when mapping the human genome, with enormous consequences for understanding human development, health, ill-health, and possibly our very survival.

Anthropocenic destruction of the environment and its impact on human wellbeing is not distributed equally worldwide; its effects are scalar. Readily apparent in places such as Dhaka, Bangladesh, where children as young as eight spend their days breathing in toxic fumes produced by leather tanning, in other geographical locations, closer investigation is required to discern how individual genomes everywhere are responding to environmental stimuli affecting health and wellbeing. In April 2017, Greenpeace reported that research has shown that plastic ingested by fish is liable to end up on our dinner plates; plastic pollution in our oceans is now so widespread, it is becoming part of the food chain everywhere.

## Behavioural epigenetics

In what follows, I first set out the surprising findings that emerged when mapping the human genome. These discoveries encouraged a burgeoning

of research in the field known today as 'behavioural epigenetics', a discipline anchored by the impact of environmental variables external and internal to the body on human development throughout the life course, from the moment of conception on. The idea of 'environment' is apparently self-evident, so much so that Raymond Williams gave it no entry in *Keywords* (Williams 1983), although he describes nature, often associated with environment, as 'perhaps the most complex word in the English language'. According to the *Oxford English Dictionary*, the earliest definition of the word 'environment' appears in the mid-eighteenth century as 'that which environs' and also as 'the objects or the region that surrounds anything' (*Oxford English Dictionary*). Contemporary dictionaries include the following meanings: 'The aggregate of surrounding things, conditions, or influences; milieu, the air, water, minerals, organisms, and all other external factors surrounding and affecting a given organism at any time and, further, the social and cultural forces that shape the life of a person or a population.' Clearly, if the notion of environment is central to any given scientific endeavour, it requires delineation, demarcation and/or contouring at the outset.

Epigenetics is being heralded as a scientific discipline that may well transcend the reductionism associated with many investigations carried out in the field of molecular genetics. However, several social scientists have expressed concern about the apparent neo-reductionism evident in the majority of projects currently being conducted under the umbrella of environmental epigenetics (Lock 2013a, 2013b; Niewöhner 2011; Richardson 2015). Several of the illustrative examples presented in this paper make it clear that a tendency exists on the part of epigeneticists to systematically scale down and miniaturise what is delineated as environment in their research projects. This practice enables standardisation of methodologies, and makes it possible to carry out all-important replication studies. The result is that economic and sociopolitical variables that contribute in profound ways to health and illness are set to one side. This is in no way to deny the importance of the molecularlised findings as such, but to suggest that if the implications of these rich insights emerging in epigenetics are to be fully grasped, then limiting accounts to the effects of proximate variables on human bodies falls short.

Epigenetics is slowly exposing certain of the molecular pathways both external and internal to the body by means of which depredating situations literally transform individual genomes; findings such as these are regarded by many scientists and non-scientists as 'hard' data, *tout court*, and such molecular profiles will almost certainly become the first line of evidence to assist in decision making in the courts and by policy

makers in connection with neglect, abuse and other forms of violence. The cases discussed below make clear how important it is that documentation of bodily epigenetic changes not be limited to proximate variables. On the contrary, when it comes to medical care, policy making and legal cases, economic and socio-political variables that impact on everyday life that have clearly contributed to the situation should be included. In addition, narratives given by affected individuals furnish invaluable data.

The field of epigenetics is young, and many research findings are at present provisional. Even so, this burgeoning specialty has the potential to bring about a paradigm shift that has already transformed the world of genomics to a considerable extent. Similarly, the fields of epidemiology and public health are undergoing a seismic shift in thinking about nosologies of ill health and early death: the effects of poverty, violence and low levels of education that have long been researched by epidemiologists and public health practitioners can now be linked directly to epigenetic changes that affect brain development and functioning throughout life. Moreover, it is increasingly clear that even if such epigenetic changes are not transmitted intergenerationally they are all too often produced anew in ensuing generations if the social conditions are not changed. Media reporting and social media make it clear that clinicians and the public at large are processing this information, although not always with the required accuracy and precaution that is needed.

## The reactive genome

Following the announcements in 2001 that the human genome had been mapped (which was not at that time, strictly speaking, true) many surprises came to light, certain of which scientists had predicted prior to embarking on the Human Genome project (HGP), but that had been ignored. It was revealed that humans have approximately 20,000 genes, and not 100,000 as had been predicted. Numerous plants have many more genes than do humans, and the diminutive worm *C. elegans* has about the same number as ourselves. The size of a genome bears no relationship to its complexity, and the genome is not a template for the organism as a whole. Only approximately 1.2 per cent of DNA segments actually code for proteins, and the remaining 98.8 per cent was initially labelled disparagingly as 'junk' (Gibbs 2003). Given that DNA is among the most non-reactive, chemically inert molecules in the world, with no 'power to reproduce itself', as Richard Lewontin puts it (Lewontin 2000, 141), it is

somewhat surprising in retrospect that so much significance was attributed to this molecule in the first place.

Non-coding segments of the genome initially appeared to have no obvious function. It soon became evident that they are frequently remnants of bacterial and viral genomes that serve to separate out the coding parts of the genome, thus inhibiting unwanted mutational changes during DNA transmission between generations. Moreover, numerous of these non-coding DNA sequences are highly conserved, implying that they have been present in genomes for hundreds of millions of years, strongly suggesting that they are crucial to both the fundamental processes of life and to evolutionary change.

Furthermore, it is well established that the activities of non-coding RNA (ncRNA) comprise a comprehensive regulatory system that functions to create the 'architecture' of organisms, without which chaos would reign. To this end, ncRNA profoundly affects the timing of processes that occur during development, including stem cell maintenance, cell proliferation, apoptosis (programmed cell death), the occurrence of cancer and other complex ailments (Mattick 2004). These findings greatly advanced understanding of the structure and function of the genome itself.

An important shift in orientation that commenced decades before the HGP, but which had remained largely quiescent, started to attract significant attention boosted by the post-genomic surprises. This shift was towards an investigation of the way in which environmental stimuli influence molecular activity. Today the majority of biologists, whatever their specialty, accept that cellular differentiation associated with human development is governed by processes akin to what was first described by the developmental biologist, embryologist, and philosopher Conrad Waddington in the mid-twentieth century as the epigenetic landscape; that is, a complex panorama of networks and feed-forward loops that determine when exactly stem cells are activated to form a lineage (Ramirez-Goicoechea 2013, 66). In other words, a chronological process that is context-specific. Numerous scientists also agree that these changes are not only initiated inside the body, but that external stimuli interact *directly* with individual genomes, resulting in epigenetic changes, or markers. Many such changes are stable, while others are reversible. Over the past decade molecular epigenetics has added numerous insights to this complex picture.

The assertion that multiple mechanisms of inheritance exist, and that variation in genomic sequences alone cannot account for phenotypic differences (Ramirez-Goicoechea 2013, 66–7) inevitably raises ontological concerns similar to those apparent in the days of Lamarck, regardless of the question of intergenerational inheritance, and epigenetics

has been described as neo-Lamarckian by some researchers. Of course, given that neo-Lamarckism is grounded in molecular biology, its original claims are significantly modified, but the central tenet that environment makes a major contribution to the characteristics that are passed along to ensuing generations informs the foundational thinking of the burgeoning discipline of epigenetics.

The philosopher of science Evelyn Fox Keller sums up the situation thus: 'The role of the genome has been turned on its head, transforming it from an executive suite of directional instructions to an exquisitely sensitive … system that enables cells to regulate gene expression in response to their immediate environment' (Keller 2014, 2425). We live now with a 'reactive genome' (Gilbert 2003, 92). Furthermore, if genes are conceptualised as in effect 'real' entities, then they should be understood as composite rather than as unitary, somewhat analogous to 'the solar system, or a forest, or a cell culture' as Barnes and Dupré put it (Barnes and Dupré 2008, 53). A dynamic epigenetic network with a 'life of its own' – a context-dependent reactive system of which DNA is just one part has been exposed. Thus, contingency displaces determinism.

Gene regulation – above all how, and under what circumstances, genes are expressed and modulated – is central to epigenetic investigation, and whole cells, rather than DNA segments, are the primary targets of investigation. Effects of evolutionary, historical, and environmental variables on cellular activity, developmental processes, health, and disease have, in theory, become central to the research endeavour in epigenetics, although, to date, this is by no means the case in most basic science investigations into genomics.

Over the past decade, then, a profound shake-up has occurred in connection with knowledge about genes and how they function. The consolidation of the field of molecular epigenetics has brought about a demotion of the gene, and challenges the unexamined assumption held by many geneticists, researchers in human development, certain social scientists, and members of the public, that genes *determine* who we are.

Two decades ago, the neurobiologist Steven Rose argued that we must be concerned above all with the *dynamics* of life, that is, with *process*, and the continuous interchange between organisms and their environments. Our 'lifelines', he argued, constituted by life processes, generate our sense of self (Rose 1997).

## Sculpting the genome

We must now ask to *what*, precisely, is the genome reactive? This forces us to consider the concept of 'environment'. Lewontin noted long ago: 'An egg, before fertilisation, contains a complete apparatus of production deposited there in the course of its cellular development. We inherit not only genes made of DNA but an intricate structure of cellular machinery made up of proteins' (Lewontin 2001, 143). For genes to function, they must be activated (switched on) and, when appropriate, deactivated (switched off) by means of complex processes bringing about differentiation that takes place at the cellular level throughout the life cycle.

The epigenetic mechanism best researched to date is methylation, a process uncovered in 1975 in which methyl groups are added to a DNA molecule. DNA methylation is found in all vertebrates, plants and many non-vertebrates and is highly conserved, indicating that it has long been involved with evolutionary change and developmental processes. Enzymes initiate such modifications that do not alter the actual DNA sequence, but simply attach a methyl group to residues of the nucleotide cytosine, thus rendering that portion of DNA inactive.

Epigenetic researchers are careful to point out that the identification of mechanisms that transmit signals from social environments external and internal to the body resulting in DNA methylation have yet to be fully worked out. But it is incontrovertibly demonstrated that methylation functions so that any given genome is able to code for diversely stable phenotypes. In other words, although every cell at the time of formation is 'pluripotent', that is, it has the potential to become any kind of mature cell, methylation brings about so-called 'cell differentiation' resulting in liver, neuronal cells, or skin cells, for example. Methylation also determines whether an embryo bee will become a drone or a queen bee, and many other such examples exist. Furthermore, methylation does not take place only *in utero* and early postpartum years, as was formerly believed, but continues throughout the life span (Meaney 2010).

An additional hypothesis that attracts environmental epigeneticists posits that DNA methylation and other related mechanisms have a second very important function, namely that these processes are not solely the result of endogenous stimuli, but are also direct responses to environmental signals external to the body that modulate patterns of cellular activity; a substantial body of research of this kind now exists (Cortessis et al. 2012; Feil and Freger 2012). In recent years, it has been recognised that such environmental exposures bring about changes to the three-dimensional chromatin fibre that compacts DNA inside cells. The idea of an epigenome

as a distinct layer over and enveloping the genome is no longer acceptable. The genome and epigenome is a flexible, commingled entity, orchestrated by shape-shifting chromatin that *may* result in hereditable changes (Lappé and Landecker 2015). In addition, strips of DNA can be damaged, often during replication, some of which changes result in mutations that may or may not be hereditable. Epigenetic mechanisms other than methylation, such as histone modifications of various kinds, also regulate gene expression, but these are as yet poorly understood. A comprehensive Wikipedia article summarises the incredible complexity and uncertainties involved in the unfolding field of epigenetics.

In summary, it is clear that genes are 'catalysts' rather than 'codes' for development (Meloni 2014), and it is the structure of information rather than information itself that is transmitted. DNA is not changed *directly* by environmental exposures. Rather, whole genomes respond ceaselessly to a wide range of environments and exposures, and chromatin mediates many such responses that, in turn, modulate DNA expression. The methylation processes described above are manifest in several timescales – evolution; transgenerational inheritance; individual lifetimes; life-course transitions (including infancy, adolescence, menopause, and old age), in addition to which are seasonal change modifications. The effects of these passages of time become miniaturised in individual bodies, making them researchable at the molecular level. This was first demonstrated using rats, discussion of which is set out below following an account of the consolidation of the field of epigenetics.

## The epigenetic explosion

The word *epigenetics* was first used in 1942 by C. H. Waddington, described in the *Encyclopædia Britannica* as an embryologist, geneticist and philosopher of science. While teaching at Cambridge University, he taught himself palaeontology and eventually became known as the founder of systems biology. Waddington wrote that the Aristotelian word *epigenesis*, even though the term 'was now more or less in disuse', was the stimulus for him to coin epigenetics (Waddington 1942). He initially argued that the new field would be limited to 'the causal interactions between genes and their products which bring the phenotype into being' (a subject that Julian Huxley had previously worked on), but broadened his argument very quickly.

Waddington's position was influenced by the dawning realisation of several researchers of his day that development of the embryo must involve networks of interactions *among* genes that form a complex

integrated system, and that the completely bifurcated subjects of genetics and embryology should be brought closer together, even though many embryologists feared that their field would be completely overtaken by genetics if such a move took place (Waddington 1940). Waddington was trained in both fields; he had worked in Germany with the Nobel Laureate embryologist, Hans Spemann, and with the geneticist Thomas Hunt Morgan in California, and made the very idea of 'development' central to his arguments specifically because of its double meaning: the growth of individuals *and* evolutionary change.

For Waddington, development denotes the set of conditions that enable so-called 'multi-potent stem cells' to become differentiated in tissues that develop into cells with specific functions. He insisted that genes are responsible for guiding only 'the mechanics of development', and argued that genotypes and environments function together to produce phenotypes. An appreciation of what continues to be recognised as 'critical periods' in developmental processes is also embedded in Waddington's thinking. He adamantly rejected reductionist neo-Darwinianism, and described himself expressly as a Darwinian.

In his book *Organisers and Genes*, published in 1940, Waddington topologically depicted 'the epigenetic landscape' as a symbolic representation of embryonic development. The image is of a ball rolling down an undulating plateau in concert with other balls, in which one of several possible pathways is taken before it eventually comes to rest at a lowest point. In the case of a pathway or 'creode' which is deeply carved into the hillside, external disturbance is unlikely to prevent normal development. The balls depict developing eggs and the gradual transformation of their pluripotent cells into tissue types, the process of which is controlled by genes interacting with each other that modulate the manner in which the egg/ball descends the slopes and select specific intersections (Figure 1.1). Waddington's point was that development is 'canalised' – thus 'buffering' the outcome of natural selection, understood today as a measure of the ability of a population to produce replicable phenotypes regardless of variability in genotypes or the environment.

Waddington's intention was to demonstrate that there is no straightforward relationship between a gene and its phenotypic effects, and furthermore that, should a mutation arise, its effects may well be moderated or buffered by other genes – a process he termed 'genetic assimilation' that he explicitly linked to Darwinian thinking. Waddington was emphatic that genetic variation and phenotypic expression are not coupled. He acknowledges that change can be random, but at the same time he argued that evolution occurs primarily as a result of mutations

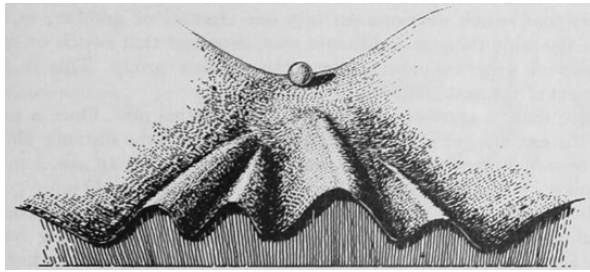

**Figure 1.1** 'The Epigenetic Landscape'. Source: Waddington, C. H. 1966. *Principles of Development and Differentiation*. New York and London: Macmillan. Wellcome Collection. CC BY-NC 4.0.

that affect developmental anatomy. His theorising influenced debates of his day about both embryology and evolution. See Petryna, this volume, for influences on Waddington's thinking by the Scottish biologist and mathematician, D'Arcy Thompson.

Waddington was clear that the metaphor of the epigenetic landscape had limitations (Waddington 1940, 92); nevertheless, this image is usually taken as the starting point for a genealogy of epigenetics. His argument that synchronic processes, both among genes and in the larger intra-cellular environment, must be incorporated into and modify linear unidirectional accounts of developmental processes and evolutionary change was in effect a paradigmatic shift. In the preface to the first edition of his book, Waddington notes that his greatest debt goes to the biochemist Joseph Needham, also an extraordinarily influential sinologist best known for his monumental seven-volume work on the history of science in China. It is reasonable to assume that the image of the epigenetic landscape was influenced to some extent by discussions with Needham who, in the 1940s, was teaching himself Chinese, and would have been well acquainted with classical understanding of disease causation in China in which inductive thinking is dominant, and bodies are embedded in encapsulating spheres of the individual, society, environment and cosmos. This type of thinking persists in modified form to the present day in the practice of traditional Chinese medicine (Farquhar 1994). Waddington was also well acquainted with Alexandrian Gnostics and the so-called Arabic alchemists, philosophers whose ideas may have contributed to his writing (Waddington 1975).

Although the majority of epigenetic researchers from Waddington's time to the present day acknowledge that social, political and economic variables contribute to the epigenetic changes that they are investigating, nevertheless they set these variables to one side and create environments

that are deliberately 'miniaturised' for the purposes of research. But such miniaturisation, although it facilitates controlled scientific investigation, is problematic when it comes to seeking out other than proximal explanations for epigenetic changes. Exposures to environments external to individuals can have profound, lasting effects on wellbeing that, if ignored, may well result in inappropriate victim blaming, as we will see in what follows.

Jablonka and Lamb, both geneticists and epigeneticists, note that Waddington's work essentially languished for the first three decades of its existence and one or two scientists argued that it should be abandoned, but it nevertheless survived to become molecularised in form. In the post-genomic era, from the early years of the twenty-first century, the field has been thoroughly revitalised and focuses on 'alternative developmental pathways, on developmental networks underlying stability and flexibility, and on the influence of environmental conditions on what happens in cells and organisms' (Jablonka and Lamb 2002, 89) – at both individual and population levels, one might add.

Epigenetics has expanded into an enormous field of inquiry that includes stem cell biology, cancer biology, investigations into genome instability, DNA repair, epigenetic epidemiology, and so on. The concept of environment, having been rendered essentially of no importance in hard-line deterministic genetics, is resuscitated in the post-genomic era to take on singular importance in the formation of reactive genomes and hence with DNA activity and cell functioning. It follows that delineating environment is crucial to understanding the biological embedding of individuals, their families and communities in specific contexts (Hertzman 1999). Of greatest interest to anthropologists is the sub-field of environmental epigenetics, a term used to cover investigations into topics as wide ranging as toxic exposures, malnutrition and abuse.

Disagreements among practitioners of this sub-discipline are evident, and the presumption that one or more teams of researchers represent the entire field would be a mistake (Landecker and Panofsky 2013; Lock 2015).

## The embodiment of trauma

An article published in the mid-1990s by the epigeneticist Michael Meaney and colleagues has become iconic in the field of epigenetics. This research made use of a model of maternal deprivation created in rats by removing young pups from their mothers shortly after birth, thus terminating maternal licking and grooming crucial to their development. The

deprivation altered the expression of genes that regulate behavioural and endocrine responses to stress, and hence, indirectly, hippocampal synaptic development (Meaney et al. 1996). It was found that these changes could be reversed if pups were returned in a matter of days to their mothers.

Furthermore, when the birth mother was a poor nurturer, placement of her deprived pups with a surrogate mother who licks and grooms them enabled the pups to flourish. Crucially, it was shown that pups or foster pups left to mature with low-licking mothers not only exhibited a chronically increased stress response but also passed on to their own pups this heightened sensitivity to stress. Hence, variation in maternal behaviour results in biological pathways causing significantly different infant phenotypes that can persist into adulthood, and are potentially transmitted to the next generation.

A sizeable body of work based largely on animal models, but increasingly in humans, substantiates these findings and broadens their significance. Since the 1990s, a literature has accrued showing a strong relationship between 'childhood maltreatment' and negative mental health outcomes ranging from aggressive and violent behaviour to suicide. Current investigations are gradually exposing how the 'biological embedding' of childhood maltreatment comes about (Jaffee and Christian 2014). The overall conclusion drawn from this research is that the 'epigenome is responsive to developmental, physiological and environmental cues' that bring about so-called 'epigenetic marks'.

In 2011 Moshe Szyf titled a presentation he gave at a Montreal gathering 'DNA methylation: A molecular link between nurture and nature'. At the time this talk was given, evidence for such a link had accrued primarily from animal research and from one human study based on a sample of 25 individuals who had suffered severe abuse as children and later committed suicide. At autopsy, the donated brains of these individuals showed a significantly different pattern of DNA methylation than did those of a control group of 16 'normal' individuals. A second control group of 20 individuals who had committed suicide but where no known abuse had taken place was also included in the study. The findings are presumed to substantiate a mechanism whereby nature and nurture meld as one. In this particular case, childhood adversity is associated with sustained modifications in DNA methylation across the genome, among which are epigenetic alterations in hippocampal neurons that may well interfere with processes of neuroplasticity (McGowan et al. 2009).

The researchers acknowledge that the sample was small, and that the study cannot be validated. The absence of a control group that experienced early life abuse and did not die by suicide is another shortcoming.

Furthermore, the abuse that the subjects experienced was exceptionally severe. Szyf and colleagues readily agree that understanding of these processes remains rudimentary. Even so, given that epigenetic markers have been shown to play important roles in learning and memory that may be transmitted intergenerationally, these findings suggest how the effects of trauma associated with events such as colonisation, slavery, war, displacement, abuse and neglect may be transmitted through time. It is also the case that they bring about insights into resilience in connection with such events (Hughes 2012).

In the remainder of this chapter, I discuss the epigenetic effects brought about by the impact of stress, malnutrition, environmental toxins and social isolation on human wellbeing. Certain populations and individuals are of course more pervasively exposed to such variables than are others. The concept of local biologies posits that the material body is everywhere inseparably entangled with specific historical, economic and socio/political variables that are deeply implicated in bringing about epigenetic changes in individual bodies. However, it is also evident, given the extent of human migration today, voluntary or forced, that local biologies must be subsumed under broader, inclusive concepts of 'situated' and/or 'emerging' biologies and that epigenetic changes can be widely distributed across vast swaths of people.

## Epigenetics and miniaturised environments

It has been demonstrated repeatedly that prenatal exposure to 'maternal stress, anxiety, and depression' can have lasting effects on infant development associated with the appearance of psychopathology later in life. A review of 176 articles, based on findings from both animal and, to a lesser extent, human research, notes: 'the *in utero* environment is regulated by placental function and there is emerging evidence that the placenta is highly susceptible to maternal distress and is a target of epigenetic dysregulation' (Monk et al. 2012, 1361). In addition to which a large body of research suggests that postnatal maternal care can induce further disruptions. Such findings are based largely on correlations, but researchers are beginning to map segments of the pathways whereby environmentally induced epigenetic marks are apparently associated with behavioural outcomes pre- and postnatally (Monk et al. 2012). Antenatal depression and anxiety symptoms are picked out for particular attention as signs of an *in utero* environment that brings about dysregulation. In other words,

the environment is effectively scaled down to molecular activity inside a single organ of the body – the uterus and its fetal contents.

In an article published in *BioSocieties*, Ilina Singh (2012) comments on a warning sent out to its members by the American Academy of Paediatrics in 2011 cautioning about the harm caused to children by 'toxic stress'. Singh interprets this warning as a move towards increased monitoring of families, notably pregnant women and young mothers who, she suggests, are likely to be targeted for observation – their behaviour subjected to surveillance designed to avoid fetal and infant stress. Medical and social support for young childbearing women is to be lauded but, as Singh states, the possibility that home visits to pregnant women, such as those being carried out through a partnership of nurses and family practitioners in New York, might well become, in effect, 'womb visits' (as seems likely to be the case in the many other cities in North America where home visits during pregnancy are the practice). The poverty and often violent living conditions of many mothers-to-be may well be virtually ignored, and attention light almost exclusively on the pregnant belly and its contents (Singh 2012). Research findings from the Mapping of the Human Brain project are providing remarkable insights into the singularity and complexity of genes that appear to put a fetus at risk for autism following birth, and it appears that epigenetic changes *in utero* are implicated.

As this research unfolds, the womb and its environments will be monitored yet more closely (Semeniuk 2014). It is clear that if molecularised findings are not systematically embedded in broader socio/political contexts, there is a distinct danger that accounting for epigenetic changes will be reduced to the presumed habitual behaviours of named populations, social groups and parents – notably mothers – who disproportionally fall into disadvantaged, impoverished and stigmatised populations.

## Agent Orange: Lasting effects in time and space

Based on many years of fieldwork that commenced in 2003 in Hanoi, Vietnam, the Danish anthropologist Tine Gammeltoft has documented the devastating effects on reproduction caused by the chemical defoliant Agent Orange that persist more than 40 years after the war (Gammeltoft 2014). The US military conducted an aerial defoliation programme throughout the war that was part of a 'forced urbanisation' strategy designed to force peasants to leave the countryside where they helped sustain the guerrillas, and move to the cities dominated by US forces.

Nearly 20 million gallons of chemical herbicides and defoliants was sprayed onto Vietnam, eastern Laos, and parts of Cambodia, destroying all plant material in 2 days. In some areas, toxic concentrations in soil and water became hundreds of times greater than the levels considered safe in the US (Schmidt 2016).

Agent Orange contains the highly toxic chemical dioxin, known to have long-lasting effects on the environment and human tissue. Gammeltoft documents a widespread fear about the so-called 'dioxin gene', widely believed by many people living in Vietnam today to be increasing in the population. It is estimated that at least 3 million Vietnamese citizens suffer from serious health problems due to exposure to defoliants, and the rate of severe congenital abnormalities in herbicide-exposed people is reckoned at 2.95 per cent higher than unexposed individuals. The media has reported cases of third-generation Agent Orange victims, in which individuals exposed during the war have produced apparently healthy children whose children are born severely disabled. Animal research has shown that, following fetal exposure, dioxin reprogrammes epigenetic developmental processes, the effects of which may become manifest throughout life and intergenerationally.

Vietnam was given membership in the World Trade Organization in 2007, one result of which was heightened concern by the Vietnamese government about the international visibility of the health of the population as a whole. It was at this juncture that extensive use of ultrasonography was introduced – a political tool designed to ensure the birth of healthy children. Ultrasound is now used repeatedly during pregnancy as part of antenatal care, even though the Vietnam Ministry of Health does not recommend this practice. Reaching a decision to have an abortion if a deformity is detected by ultrasound is not easy, particularly because many affected families think that abortion is an evil act. Everyone involved knows that it can be difficult to assess the extent of a deformity from ultrasound images, although it is equally the case that frequently it is all too evident. Some families, opposed to abortion, and longing for a healthy child, are raising three or four children with deformities, the most common of which is hydrocephalus ('water on the brain') that causes severe retardation. A few women discover very late in a pregnancy that their fetus is not normal, and some opt then for a late termination, to the great discomfort of their doctors.

Gammeltoft's interviews with affected families make clear that many people choose not to entertain the idea that an anomalous fetus or the birth of a horribly deformed child is due to Agent Orange. They

are all too well aware that the stigma attached to Agent Orange families ensures that finding marriage partners for healthy members of the family becomes virtually impossible. Better to claim publicly that the anomaly resulted from a common cold that the mother had, or the heavy work she did while pregnant (Gammeltoft 2014, 47–50).

A range of severe illnesses are associated with dioxin exposure, including deadly cancers, Parkinson's disease, and spina bifida, in addition to those associated specifically with pregnancy. Vietnamese researchers have reported these findings, but the official US position is that there is no conclusive evidence that herbicide spraying caused health problems among exposed civilians and their children. However, following extensive lobbying over many years, in 2014 the US Congress passed a five-year aid package of $21 million that amounted to a modest sum for each US veteran of the Vietnam War. These cases were settled out of court and no legal liability has ever been admitted. The official position to this day is that the government was in effect prodded into settling these legal suits and that no evidence exists that Agent Orange caused harm, and this position is supported by its principle makers, Monsanto and Dow Chemical companies. Children born to Vietnam War veterans who have birth defects may be eligible for compensation that varies according to the perceived level of disability.[1]

In Vietnam, officials were reluctant to press complaints about Agent Orange because uppermost were concerns about the economy as a whole, notably a desire not to damage the marketing of numerous agricultural and aquacultural products made in Vietnam today. In the mid-1990s, Vietnamese writers and artists began to express concern about Agent Orange, and eventually Vietnamese citizens filed a class action suit in the US District Court in New York that was abruptly dismissed. However, belated demands for responsibility are increasingly being heard, spearheaded by non-governmental organisations. In summary, local biologies not only persist across generations; they also travel through space.

## Food as environment

Globally, nearly 2 million children die from malnutrition each year. Research has revealed significant findings about biological differences between infants who suffer from marasmus as opposed to kwashiorkor[2] (Forrester et al. 2012). This impressive study carried out in Jamaica commenced in 1962 and continued for 30 years; during this time over 1,100 infants with severe acute malnutrition were admitted to University

Hospital, Kingston. It was found that those infants diagnosed with kwashiorkor had considerably higher birth weights than did infants diagnosed with marasmus. The authors concluded that mechanisms associated with physiological 'plasticity' are operative *in utero* and that these children have distinctively different types of metabolism. Of the two conditions, children more often die from kwashiorkor, associated with edema, although less wasting takes place as compared to marasmus. Children diagnosed with marasmus do not become edematous, but endure much greater wasting of their flesh, although their survival rates are better than those of children with kwashiorkor.

Researchers characterise marasmus as 'metabolically thrifty', and kwashiorkor as 'metabolically profligate'. They propose that in the case of children with marasmus, when the maternal diet is low in nutrition, fetal metabolism *in utero* in effect 'anticipates' a postnatal environment of scarcity, and low birth weights are assumed to be evidence of this process designed for survival. The authors argue that this finding provides the first direct evidence in humans in support of the fitness-enhancing effects in childhood of 'anticipatory responses' *in utero*. Hence, the distinctly different phenotypes of children with kwashiorkor and marasmus are understood as the endpoints of epigenetic activity on genotypes *in utero*.

Nutritional epigenetics is a field attracting a great deal of attention in part because it is hoped that it will throw light on the so-called obesity epidemic currently affecting many countries, whether affluent or not. The same team that carried out the research reported above argues that growing evidence exists of 'developmentally plastic processes' that, in addition to lifestyle and individual genotypes, contribute significantly to obesity (Forrester et al. 2012). No claim is being made that such developmental pathways in which methylation processes are involved cause obesity directly, but that the risk of individuals genetically predisposed for developing obesity in later life is increased.

Based on a hypothesis known as the 'mismatch pathway', it is posited that 'evolved adaptive responses of a developing organism to anticipate future adverse environments' can have maladaptive consequences if the environment is not what has been 'biologically anticipated'. In other words, if fetuses and young infants are exposed to nutritionally deprived diets, their bodies may be epigenetically prepared to deal with deprivation as they mature, as the marasmus study suggests, a situation that can cause havoc in energy-rich environments. In addition, maternal diabetes, maternal obesity and infant overfeeding are associated with increased risk of obesity in adult life (Gluckman and Hanson 2006). Clearly this account resembles the thrifty gene hypothesis put forward in 1962 by James Neel,

an argument now outmoded in the post-genomic era; discussion about thrifty phenotypes has superseded it (Watve and Yajnik 2007).

Hannah Landecker argues that researchers presently understand food as an 'epigenetic' factor that functions in the regulation of gene expression, in turn, linked to several medical conditions including cancer, metabolic syndrome, obesity and diabetes. In other words, food is a form of 'environmental exposure' (Landecker 2011, 167) in which the environment is molecularised as food chemistry so that 'the body's molecules [are] hung in the same network of interactions as environmental molecules, a network anchored and organised through the temporarily sensitive interface of metabolism' (Landecker 2011, 176). Landecker argues that this is a model 'for how social things (food, in particular) enter the body, are digested, and in shaping metabolism, become part of the body-in-time, not by building bones and tissues, but by leaving an imprint on a dynamic bodily process', namely, the expression of genes (Landecker 2011, 177).

## Eliminating stunting

The President of the World Bank, Jim Yong Kim, a physician/anthropologist, has announced that he will 'name and shame' countries that fail to tackle the malnourishment and poor growth of their children (Boseley 2016, 1). Kim is clear that 'stunting', that is, children with height considerably below the average for their age, is not only a humanitarian disaster but also an economic one. His position is that fetal malnutrition during pregnancy and early childhood leads to serious neurological deficits, particularly in toxic environments, where recurrent infections are common, and when infants are given little or no stimulation. Kim stresses that stunted women frequently give birth to children who become stunted, with the result that 'Inequality is baked into the brains of 25 per cent of all children before the age of five' (Boseley 2016, 1). Crude estimates suggest that stunted children in India approach 40 per cent, in Pakistan 45 per cent, and in DR Congo 43 per cent; hence, Kim insists, 'the most important infrastructure we can invest in is grey matter'. He seeks to rid the world of stunted children by 2030 by donating conditional cash transfers to mothers of stunted children, thus enabling them to feed and stimulate their children through play. It is reported that a trial run in Peru worked well (Boseley 2016, 2).

Jim Yong Kim plans to repeatedly bring up 'this stain in our collective conscience' at World Economic Forums in the coming years. Clearly interventions to eliminate stunting are of enormous importance, but key socio/economic variables noted by Kim have been set to one side in his Peruvian

project, including unremitting poverty, unequal distribution of land and other resources, and increasingly toxic environments. In addition to which is the violence and counterinsurgency so evident in that country, ably documented by the anthropologist Kimberley Theidon (2013). The horrendous effects of climate change must now be added to this list.

## Toxic living

For a decade or more, researchers have been working to elucidate the effects on neurodevelopment of exposure to neurotoxins *in utero* and during early life. Recent work has highlighted epigenetic effects and an apparent intergenerational aftermath of such exposures. A 2006 review of an array of 201 neurotoxins, ranging from arsenic to benzene and PCBs, concluded that exposure to hundreds of industrial chemicals is potentially damaging to the developing brains of children worldwide, although it is noted that both timing and the amount of exposure are significant (Grandjean and Landrigan 2006). Evidence links environmental pollutants to epigenetic marks associated with a range of disease endpoints, although it is emphasised that many of these changes have been shown to be reversible and hence preventive measures are feasible (Senut et al. 2012). Lead is the most closely researched toxin to date; it has been shown repeatedly that there is no safe level of exposure during the early years of development and that it causes many epigenetic effects. Decreased brain volume is recognised as lead-related brain atrophy, and is most pronounced in males (Cecil et al. 2008). Research has also shown negative effects of lead exposure on language function (Yuan et al. 2009).

Markowitz and Rosner graphically describe the ongoing lead paint scandal in the US that has steadily unfolded for more than a half-century (Markowitz and Rosner 2013). Over the years, millions of children have been exposed in their homes to potential lead poisoning, although reliable numbers are not available. It is estimated that today over 500,000 children between 1 and 5 years old have lead levels above that which policymakers currently regard as a safe level. Reminiscent of the infamous Tuskegee experiments conducted on African-Americans, 100 children, mostly African-American, some less than a year old, living in poor family dwellings where lead paint had been used, have been systematically studied for the effects of lead exposure on their development. A judge who presided over a lawsuit described these young research subjects as 'canaries in the coalmine' (Fowler 2013).

It has been shown that lead released from a woman's bones during pregnancy can increase risk for preterm deliveries and low birth weight and, further, affect gene expression in infants involving changes to DNA methylation that may well have lifelong effects. One researcher is quoted as stating: 'lead exposure, rather than a poor social environment, is a key contributor to […] subsequent cognitive and behaviour problems' (Radiological Society of North America 2009). Such a claim prioritises one variable over another, causing a distortion. It is highly likely that lead exposure does irreparable harm to all humans, but those individuals who are at the greatest risk of being exposed are almost exclusively economically deprived. In 2014, in the impoverished town of Flint, Michigan, with a population of 100,000, nearly 60 per cent of whom are African-American, a water crisis exploded. It became clear that between 6,000 and 12,000 children had been extensively exposed to lead contamination when, in order to save money, the Flint water source was changed from a safe source, to one involving use of ageing pipes linked to the Flint river that leached lead into the water supply. As one commentator stated, 'some of the darkest chapters in American industrialisation are written in lead' (El Akkad 2016) and we learnt recently that 'Dozens of California communities have seen recent rates of childhood lead poisoning that exceeds those of Flint, Michigan' (Schneyer and Pell 2017).

Thanks to the intrepid battle fought by Rachel Carson, dichlorodiphenyltrichloroethane (DDT) was banned in the early 1970s, first in the US and then worldwide, although it continues to be used in certain malarial regions. Furthermore, the use of polychlorinated biphenyls (PCBs) is banned or severely restricted in most countries today, but about 10 per cent of the PCBs produced since the late 1920s remain in the environment today. They are released into the environment primarily from incinerators and build up in the fatty tissues of animals living in water or on land and are passed along the food chain to humans. Dioxins are found throughout the world and accumulate in the food chain, mainly in the fatty tissue of animals. They are highly toxic and cause reproductive and developmental problems, damage the immune system, interfere with hormones and cause cancer. Dioxin enters the environment primarily from incinerators; of the 419 types of dioxin-related compounds, 30 have significant toxicity (WHO 2016, 2).

The effects of PCBs, dioxin and other toxins in the Arctic are more devastating than elsewhere. Legislation against these chemicals is not effective in the extreme north as yet because toxic residues slowly drift toward the Arctic and accumulate there, making it one of the

most contaminated places on earth. The body fat of seals, whales and walruses hunted for food is highly contaminated, as is the breast milk of many Inuit women. An Inuit grandmother, politically active in circumpolar meetings, is quoted as stating: 'When women have to think twice about breast feeding their babies, surely that must be a wake-up call to the world' (Johansen 2003, 479). The situation is exacerbated because the cost of store-bought food is beyond the reach of many Arctic residents.

## The intergenerational transmission of toxins

An illustration of toxic local biologies is furnished by the mercury-contaminated Grassy Narrows' Wabigoon River system in Ontario, Canada. The government claims that defilement of the river stopped 40 years ago when the paper mill was forcibly shut down, after dumping about 9,000 kilograms of mercury into the downstream river. Today mercury levels in the fish near Grassy Narrows are 15 times the safe consumption limit, and 40 times the limit for children, pregnant women and women of child-bearing age (Mosa and Duffin 2016). The Grassy Narrows people have fought for 45 years for a clean-up of the river, but the Ontario Minister of Environment reiterated in May 2016 that there is no need for this. Further pressure apparently made the government temporarily change its position, but in late 2016, once again, the provincial government backed down, claiming a lack of funding, despite an official report by mercury experts stating that the river remains badly contaminated. Two generations of people from Grassy Narrows and Wabaseemoong First Nations today exhibit symptoms of mercury poisoning, including loss of muscle coordination, numbness in the hands and feet, hearing loss, speech damage and tunnel vision. Fetuses are particularly vulnerable to cognitive damage. Extreme cases result in paralysis, insanity, coma and death (Mosa and Duffin 2016).

In the mid-1950s, mercury poisoning was detected in Japan. First, the local cats appeared to go crazy and some 'committed suicide' by 'falling' into the sea. Thereafter, humans started to report numbness in their extremities; tremors; difficulty walking; and some appeared to be seriously mentally ill (Kugler 2016). By 1959 it had been established that mercury poisoning was causing the symptoms, and the condition was labelled Minamata disease, drawing on the name of the fishing village

where it had first occurred. A large petrochemical plant in Minamata, Chisso Corporation, was immediately suspect. Chisso denied involvement, even though it was clear that an estimated 27 tonnes of mercury compounds were present in Minamata Bay. Protests began in 1959, but it was 1968 before the company finally stopped dumping. Close to 3,000 people contracted Minamata disease, more than half of whom have died. Japanese scientists have been summoned to Grassy Narrows, and state that up to 90 per cent of the people show signs of mercury poisoning that may well be intergenerationally transmitted (Mosa and Duffin 2016).

## Social isolation

Research carried out with Romanian children living in orphanages has made clear that a paucity of social relations can bring about significant lifelong harm that may well have intergenerational effects (Nelson et al. 2013). A randomised clinical trial was carried out in which over 60 orphans aged between eight and nine were moved into good foster-care homes, at the expense of the involved researchers from the US, while a control group of similar size was left to languish in the orphanage. The study demonstrated, perhaps not surprisingly, that foster care was much more effective for the wellbeing and development, mental and physical, of these young children than was the orphanage setting in which a single adult may be responsible for 12 to 15 children. But of particular interest were findings that, as compared with never-institutionalised children, the orphaned children exhibited less development in both the grey and white matter in their brains. Foster placement quickly improved development of white matter, although grey matter development did not recover. Furthermore, the majority of institutionalised children showed shorter telomere lengths. As Elizabeth Blackburn, who has worked her whole life on telomeres, has argued, short telomeres 'powerfully quantify life's insults' (Blackburn and Epel 2012, 170). These findings were communicated to the Romanian government. Efforts to map the molecular epigenetics pathways of these findings, and those obtained from other orphanages, are now underway with some success (Naumova et al. 2012). Longitudinal ethnographic research could enrich these findings greatly, and has the potential to influence policy making.

Charles Nelson, a cognitive neuroscientist, has carried out research in Bangladesh and reports that 'the level of poverty is mind-boggling'

(Hamzelou 2016). He notes that a family of five often lives in a single room; kitchens and bathrooms are communal for an entire compound; latrines flood during the long monsoon season; people cook with wood or coal and the pollution is, as Nelson puts it, 'unbelievable'. What is more, dirt blows everywhere from unpaved tracks, and the sewers are open. Nelson states emphatically, 'the polite way to put it is that stool gets into *everything* … virtually all the children have chronic diarrhoea, which leads to malnourishment and stunting; up to 30 per cent of the mothers are visibly depressed, and high levels of domestic violence exist'. Nelson made a rule that his team must not cry in front of the children. They witnessed tiny babies left to cry in their sodden cribs, and were informed that they were rarely picked up and held (Hamzelou 2016). Neuroimaging research is now underway in a new centre constructed at great expense in Dhaka designed to track the brain development of these children.

## Colonisation and historical trauma

This final example makes clear how lasting the impact can be on individuals and groups when systematic efforts are made by invasive forces to overtake and transform groups of people *en masse*. Canada is home to roughly 1.2 million individuals who endorsed the category 'Aboriginal' in the 2006 Canadian census. The majority of these people live in communities that continue to contend with the devastating legacy of settler colonialism, including entrenched poverty and invidious discrimination manifested in so-called 'mental health' problems of many kinds. These include substance dependence, depression, violence, and extraordinarily high rates of suicide, especially among young people, estimated in some Inuit communities to be six times the rate in other parts of Canada (Kral 2012).

Independently, mental health professionals and individuals living in First Nations communities have consistently associated these high rates of pathology with the experiences of colonisation that commenced five centuries ago. A concept of 'historical trauma' has been adopted to call attention to the collective, cumulative, and intergenerational psychosocial effects that resulted from past colonial subjugation and persist in abated form to the present day (Niezen 2013).

Among the early travesties was the introduction of infectious disease. The mortality rate from infectious disease as a whole was extraordinarily high – on Haida Gwaii, for example, it is documented that between 1700 and 1900, smallpox, measles, dysentery, TB, influenza, and other

communicable diseases wiped out many thousands of people. The Haida Nation, with whom Franz Boas worked for some time, went from an estimated population of 20,000 prior to 1770 to less than 600 by the end of the nineteenth century (Kil'iljuss (Barb Wilson) 2009). The full effects of population decimation are rarely fully appreciated: given the climate and an economy based on hunting, the ability of those that survived to procure food is in effect destroyed, and hence individuals 'with the dubious good fortune of living through the initial sickness die of hunger' (Daschuk 2013, 12).

This massive population destruction was followed by extensive efforts to 'whiten' the Indians, among which was the establishment of residential schools created expressly to 'kill the Indian and save the child'. Young children were rounded up by school administrators, members of the Royal Canadian Mounted Police, and agents attached to the despised Bureau of Indian Affairs to be sent great distances from their homes, in order to be housed in institutions where they were not permitted to speak their own languages or participate in anything regarded as cultural practice (Carr 2013). Today, the residential schools, the last of which were closed down only in the 1990s, are regarded among First Nations and Inuit communities as the primary source of their current malaise. It recently came to light as part of the ongoing Truth and Reconciliation Commission of Canada, that repeated sexual abuse took place in these schools, one of which was characterised by an investigating Supreme Court Justice as practising 'institutionalised paedophilia' (Carr 2013, 19). Systematic nutritional medical experimentation was also practised on some of the students resulting in malnutrition in many, and death for many more. TB was rampant, and few attempts were made to curb it. In one notorious school, the death rate of children was apparently 75 per cent in the first 16 years of the school's operation (Carr 2013; Niezen 2013). The majority of individuals who grew up in these conditions, now middle-aged and older, have until very recently been unwilling to ruminate about their younger lives, but many freely admit to being unable to adequately parent their own children.

Despite major changes for the better in recent years, racism and discrimination continue to be blatantly evident against First Nations. Shocking poverty persists on many reservations, a good number of which have no running water and where toxic contamination is frequently present; schools on reservations are poorly provided for compared with schools elsewhere in Canada, the education gap has increased in recent years between First Nations children and other Canadians (Friesen

2013), and alcohol and drug abuse and violence against women and children is extraordinarily high.

Not all reservations exhibit high rates of illness and suicide. Some survivors report that they enjoyed school, and others became devout Christians – a conversion that apparently assisted in their survival. Clearly, differences among First Nations are of the utmost importance when attempting to account for malaise. Also, ongoing land claim settlements have improved the lot of some First Nation communities, but settlements have not been made with the majority of communities. Furthermore, the establishment of healing programmes and suicide prevention gatherings conducted by First Nations themselves, that make use of indigenous healing practices together with biomedicine, exist in certain communities and receive some government support. Such changes are regarded as a positive form of empowerment by many First Nations leaders, but are not as yet broadly entrenched (Niezen 2013).

First Nations received a formal apology from the Prime Minister of Canada two years ago but since that time the budgets of 12 government-funded programmes for First Nations have been cut, and nine of these programmes are now closed (Bennett 2013). And suicide rates, substance abuse, and the disappearance and death of young First Nation women continue to be extraordinarily high (Leblanc 2014). If the concept of 'historical trauma' is to be taken seriously, then a great deal more than an apology and a reconciliation commission are needed to counter the crudely racist attempts to obliterate the Indian – the effects of which are being played out among third and fourth post-colonial generations. It is not known if intergenerational transmission of DNA modifications has contributed to this situation. Very understandably, First Nations individuals are reluctant to donate tissue for post-mortem analysis; but obviously demonstration of epigenetic changes are not required to verify the extent and depth of this ongoing abuse that a good number of survivors of residential schools and their offspring describe as genocide (Niezen 2013).

## Conclusions

The concept of 'environment' has taken centre stage in the era of the Anthropocene. It is recognised that genes rarely determine who we are, as was formerly believed to be the case but, rather, that the human genome ceaselessly responds to environmental stimuli that impinge on it, with a lifelong influence on individual development, health and wellbeing. This recognition is designated as the post-genomic era, and the molecular

mechanisms that facilitate interactions among environments external and internal to the human body are steadily being elucidated in the burgeoning field of epigenetics. These molecular insights are of enormous significance, but the majority of epigeneticists, although they acknowledge the contributory effects of environment writ large on human bodies, nevertheless deliberately miniaturise the environment and delineate the target of investigation as proximal and/or internal to the body. This practice of scaling down the environment has been described by social scientists as neo-reductionistic.

The illustrative examples set out above make clear how social, political and economic variables impinge on the lived experience of individuals, families and communities, with profound effects on the incidence and distribution of health and illness. The effects of social isolation, extreme unremitting poverty and forced migration have particularly devastating effects on wellbeing, often with lasting intergenerational effects. The findings set out above suggest that investigative collaborations of epigeneticists working with social scientists, epidemiologists, public health researchers and historians could be very fruitful. In recent years, certain epidemiologists have entered into such collaborations (see, for example, Relton and Davey Smith 2012), and anthropologists are also becoming involved in both the design of research projects and the collection of data (Roberts 2016). The most effective of these projects are those in which 'environment' is explicitly delineated or contoured for the purposes of any given investigation, with full awareness that doing so is a device, with unavoidable limitations. Deductive thinking is not abandoned, but is greatly supplemented by attention given to interrelated, overlapping orbits that contain dense webs of partial knowledge, on the basis of which interpretive accounts can be readily discerned and explicated.

## Notes

1. https: //www.benefits.va.gov/compensation/claims-special-birth_defects.asp.
2. Marasmus and kwashiorkor are two common forms of serious protein-energy malnutrition.

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# Chapter 2
# Situating Biologies: Studying Human Differentiation as Material-Semiotic Practice

Jörg Niewöhner

## Introduction: Differences in anthropology and biology

How can anthropology and biology conceptualise and study human differentiation beyond biodeterminism as a material-semiotic practice? Differences that make a difference have always been of central concern to social inquiry. Such differences matter on at least two distinct levels: As differences 'out there' in the world, and as differences in the analytical categories that social inquiry employs and develops. The two levels are interdependent, i.e. they are connected through manifold and often messy looping effects (Hacking 2007). One such form of difference-making is commonly referred to in the social sciences as 'social differentiation'. People living in groups, so the argument goes, differentiate into subgroups. The complex processes driving and shaping social differentiation are fundamental to social life. They can be discerned, for example, as interactional and situational markers of distinction or as structural or dispositional factors implicating power, knowledge and distributional matters. Social differentiation becomes of particular concern to the social sciences where patterns of significantly unequal distribution of means and types of capital within a group emerge, manifest and reproduce over time. Such patterns raise important political and ethical questions – not least, because epidemiological research persistently shows that people within the relatively disadvantaged sections of these distributional patterns display a significant tendency to fall ill more often and die earlier compared to those in the relatively better-off sections (Marmot et al. 2001). The

analysis of differentiation processes has typically followed established modern distinctions between nature and culture: social differentiation is a matter of people interacting studied by the social sciences; the biological consequences are suffered by humans whose biology is investigated by the natural sciences and biomedicine. The great divide may be bridged briefly by statistical correlation. Yet the majority of attempts to explain or interpret differentiation have assumed that it is *either* matter *or* history 'all the way down' (Haraway 2008). Those favouring matter have clearly dominated research since the end of the last century.

This volume is now suggesting that such biodeterministic thought styles are being troubled in productive ways; that the relations between nature and culture are being reconfigured; and that an opening may be emerging to study and think through environment/human entanglements differently. In this chapter, I want to contribute to this line of thought by investigating social differentiation as a biosocial phenomenon in the sense that the introduction to this volume is putting forward. I am arguing that the social sciences benefit from taking seriously the material dimensions of social differentiation and that the biological sciences benefit from reflecting on their understanding and operationalisation of social practice. Both disciplines, I suggest, need to find ways of 'staying with the trouble' (Haraway 2016), i.e. of engaging with those thought styles, findings and methods, which they so easily consider the respective 'other' to their own everyday knowledge practices; not in order to build a comprehensive theory of biosocial differentiation, but to foster new forms of reflexivity within the respective disciplines and move beyond unproductive modern and ultimately determinist dichotomies. I build my argument by presenting two examples of studies of 'social' differentiation. One is anthropological and gleaned from the literature, the other taken from my own ethnographic laboratory study of epigenetic research. I then diffract these cases, i.e. read them through each other to reveal their respective blindsidedness as well as opportunities for mutual engagement. Drawing on Margaret Lock's notion of local biologies (Lock 1993a, 1993b and this volume), I argue in favour of 'situating biologies' as a research agenda capable of addressing – as this volume has it – 'biosocial becomings'. Situating biologies is a collaborative agenda between anthropology and biology that focuses on bodies-in-action as the basic unit of analysis (see Lock and Napier, this volume) and that understands differentiation as a patterning of material-semiotic practices (Roepstorff et al. 2010).

## Empirical sketch I: Inscribing difference into the body – an anthropological perspective

Northern England: Picture a 30-year-old man, unemployed, who ekes out a living by boxing on the local fight circuit. In an interview with the anthropologist Simon Charlesworth, he describes what happened to him as he entered the social security office's waiting area with a seat available next to what he perceived to be a middle-class woman:

> '… it's all arahnd us, Ah went in't social (Social Security Office) other day … there was like this chairs an' a space next to this stuck up cow, yer know, slim, attractive, middle class, an' Ah din't wanna sit wi'y 'er, yer feel yer shun't, Ah become all conscious, of ma weight, Ah felt overweight, Ah start swettin', Ah start bunglin', shufflin', Ah just thought "no, Ah'm not gunna sit there, Ah don't wanna put her aht", Ah dun't wanna feel that shi's put aht, yer dun't wanna bother them … yer know you insult them … way thi' look at yer like the're disgusted … thi' look at yer like yer invadin' their area … yer know, Straight away, way yer tret … yer feel "Ah shun't bi there" … it meks yer not want to gu aht … What it is, it's a form of violence, … right, it's like a barrier sayin' "listen low life don't even [voice rises with pain and anger] come near me! … What the fuck yer doin' in ma space? … Wi' pay to get away from scum like you" … It fuckin' stresses you, yer get exhausted … It's everywhere … Ah mean, Ah clocked her like they clock us, right, … an' thought "fuck me, Ah ain't even sittin' there". She would be uncomfortable, an' it'll embarrass me, yer know, [voice rises in anger/pain.] Wi' wo' just sittin' there, yer know what Ah'm tranna say? … It's like a common understandin', yer know ahr they feel, yer feel it, Ah'm telling yer … They are fuck all, thi' got nothin', but it's that air abaht 'em, yer know, thi've got the right, the body the clothes, an' everythin', the confidence, thi' attitude, know what Ah mean … We [sadly, voice drops] an't got it, wi can't 'ave it. Wi' walk in like wi' been beaten, … draggin' ahr feet when wi' walkin' in, … yer like feel like yer want to hide …' (Charlesworth et al. 2004, 51ff.)

This is an intense statement. It gives an almost painful insight into 'living inferiority' as lead author Charlesworth calls it, i.e. an insight into the manifold effects of the daily workings of social differentiation within societies. Many aspects from this quote could be discussed. I want to pick out two of them:

1. What this man experiences is not triggered by any problematic action as such. He does not witness or is not subject to an openly discriminatory act. There is neither open aggression in this situation nor any verbal or physical violence. He is not excluded or marked in any active way by an in-group. Nothing really *happens* in this situation at all. Rather, the man is positioned within social space or, perhaps more accurately, positioned within what has been called kairotic space to emphasise the often informal nature of power and discrimination operating within material and social space (Price 2011). The social situation affords an awareness of the particular social stratification of the society within which it takes place.[1] The social situation 'in the waiting room' forces two very different people next to each other and thus affords a comparing and differentiating experience of this particular constellation. Needless to say, this experience necessarily draws on wider discourses of social class and also extends the specific situation into social history, biography and milieu. I use the notion of affordance to emphasise that the social situation does not determine personal experience. Other responses would have been possible: for example, a proud feeling of superiority based in a sense of working class belonging. Yet it is not the individual's free choosing that determines his experience either. The material and semiotic environment of this social situation, for example, the waiting room with its chairs, the specific availability of narrations of class in English public discourse, the established markers of appearance and distinction materialised in clothes and carried in style, all of these characteristics of the situation afford a certain response, interpretation and experience. My point here is that social differentiation is an ever-present and unavoidable phenomenon in human societies. Yet its specific experience by individuals in everyday life situations is always mediated and open to interpretation. It is contingent.
2. The quote illustrates perfectly why it often seems so meaningless or at least artificial to separate 'the body' from 'the social' and 'the environment'. It is obvious here that this man's body is implicated in the situation in multiple ways: the body carries signs of distinction (overweight, hair cut, etc.), hence contributes to the affordance of the situation. The body also appears to bear the consequences of this situation as experienced by the man as a social being: sweating and feeling overweight are two signs that the man verbalises. A biomarker measurement in this situation would probably indicate an acute stress response with an activated

hypothalamic-pituitary-adrenal axis, increased glucocorticoids and circulatory activity, etc. The paper's authors draw heavily on Pierre Bourdieu to emphasise this moment of inscription of social phenomena into the material body:

> We learn bodily. The social order inscribes itself in bodies through this permanent confrontation, which may be more or less dramatic but is always largely marked by affectivity and, more precisely, by affective transactions with the environment … it would be wrong to underestimate the pressure of oppression, continuous and often unnoticed, of the ordinary order of things, the conditionings imposed by the material conditions of existence, by the insidious injunctions and 'inert violence' (as Sartre puts it) of economic and social structures and of the mechanisms through which they are reproduced. The most serious social injunctions are addressed not to the intellect but to the body, treated as a memory pad. (Bourdieu 2000, 141, cited in Charlesworth et al. 2004, 57)

The material body is thus part of the cause and the consequence of this social situation. In fact, it is very hard to even speak of the material body without emphasising its social aspects. Yet while the social sciences have pointed to inscription, i.e. the material manifestation of social processes, they did not follow through to study the fate of these material manifestations and their continued role in social practices.

## Empirical sketch II: Inscribing difference – a molecular biological perspective

Environmental epigenetics is a research field within molecular biology concerned with biochemical and structural changes of DNA molecules that do not involve DNA sequence change, but that have an effect on gene expression (for example, Tost 2008). The two most commonly studied changes are methylation and histone modification. In methylation, a methyl group binds to a section of the DNA sequence blocking its transcription. In histone modification, the folding of the DNA molecule is changed such that the transcription machinery cannot attach and move along the sequence properly. In both cases, the altered gene (or DNA sequence) is not expressed. Epigenetic changes occur 'naturally' in plants and animals during organismic development. They are commonly thought of as a switch-like mechanism to regulate genes up or down depending on the need for particular proteins during particular developmental stages and

processes. Environmental epigenetics, sometimes also called behavioural epigenetics, is an emerging subfield of epigenetics concerned with epigenetic changes that occur in response to changes in an organism's environment (for example, Jirtle and Skinner 2007). Environment in this context includes the material (for example, food or toxins) as well as the social environment (for example, behaviour or stress) if one cares to analytically distinguish the two clearly. Epigenetic changes are commonly tissue- and even cell-specific and they are thought to be 'metastable', i.e. they occur in response to a particular event and then track through mitotic and meiotic reproduction. They can be passed on to future generations without altering the germ line.[2] Research demonstrates that epigenetic changes acquired during adulthood can be passed on to at least the grandchildren generation. In summary, epigenetic research presents a set of molecular mechanisms that link environment to gene regulation within an organism. The implications of such a reactive genome (Keller 2014) for evolutionary theory have been discussed in detail (Jablonka and Lamb 1998); as have the social scientific implications and politico-historical contexts within which this research is set (Lock 2015; Landecker and Panofsky 2013; Meloni 2016, 2019; Niewöhner 2011).

Environmental epigenetics is a relatively small but rapidly expanding field of research. Recent proof of concept experimental work that was published high profile in *Nature, Neuroscience* and *PLoS One* has placed the field on the molecular biological map and also attracted initial interest from the social sciences (see Waterland 2003; Weaver et al. 2004; McGowan et al. 2009; for social science discussion of studies, see Niewöhner 2011). As Maurizio Meloni has shown, environmental epigenetics is joined by efforts such as sociogenomics or social and cultural neurosciences in trying to experimentally understand the functional and mechanistic links between biological matter and the wider (social) organismic environment (Meloni 2014). Environmental epigenetics then is a field of interest when trying to redress the boundary work between nature and culture, society and the body, performed by the biological and social sciences.

## Molecular biology of social position

The preceding paragraphs have outlined current research priorities in epigenetics and situated the subfield of environmental epigenetics in a wider life scientific trend. To understand how environmental epigenetics produces the entanglement of nature and culture in practice and

how this may be good to think with in social science, it is necessary to leave this macro level of analysis and turn to a specific case: the molecular biology of social position. To illustrate this case, I will draw on published material as well as ethnographic findings from a four-month lab ethnography with the lab of cancer biologist and epigenetics researcher Moshe Szyf at McGill University, Montreal in 2009. The study on which I will focus has been published in the *International Journal of Epidemiology* in 2012 (Borghol et al. 2012). It is concerned with the impact of an individual's socio-economic status (SES) on his or her epigenetic profile. It tries to answer a question very similar to the one pursued in the first empirical sketch: given that society is socially stratified, what marks does this leave on the body? Rephrased in the group's epigenetic terms: how does social position impact upon methylation patterns? To conduct this study, the group links up with a well-defined, long-term epidemiological cohort study in the UK, the 1958 birth cohort study (see Power et al. 2008). This cohort was set up in 1958 to include all people born in one week in March of that year in the UK. It has gathered data on many aspects of public health, including the link between cardiovascular risk factors and measures of socio-economic status or social position as epidemiology often refers to this indicator. In one of the latest follow-ups in 2003, blood samples were taken from the then 45-year-old participants. This availability of epidemiological data and blood samples has opened up the opportunity for an experimental design that connects social variables with biological markers. This is not only of interest to epigenetic researchers. It is also important for the gatekeepers of the epidemiological cohort. If their hypotheses are confirmed, epigenetics could underpin the well-established 'social determinants of health' theory with a molecular mechanism (for example, Brunner et al. 1997; Marmot et al. 2001). In collaboration with the epidemiological cohort, Szyf's group sets up a study with samples from 40 people of maximally different social positions at birth and age 45 respectively. Their aim is to detect how changes in social position correlate with methylation patterns. Rooted in the above discussions on social status as relational and further underpinned by theorising on evolutionary and developmental adaptation (Gluckman et al. 2005, 2009), the group's initial hypothesis is that methylation patterns might correspond to changes in social position independent of the direction of change, i.e. towards better or worse positions. The idea is that any departure from the initial social position, i.e. the social position to which a newborn's biology is adapted, will require biological adjustments, which in turn will leave measurable traces in the body. This hypothesis cannot be confirmed by experimental findings as

such. The study in the end shows that social position during childhood – measured as parental occupation and access to household amenities – is a better predictor of adult methylation pattern than social position at the time of methylation measurement – measured as current occupation and housing tenure (Borghol et al. 2012). This finding is interpreted as evidence for the fact that early life social position writes itself into biology in ways that are at least semi-stable. Early life effects 'track' into adulthood, as epidemiologists often call it. While tracking is well known, this study points to a possibly relevant molecular mechanism underpinning this process. It suggests a mechanism that links the social environment directly with physiology. This effect and pathway is known from research on rats (Weaver et al. 2004) and has been further supported by research on human suicide completers (Labonté et al. 2012, 2013; McGowan et al. 2009, 2011). Many of these studies have been discussed at some length in the social science literature (Meloni 2014; Landecker 2011; Landecker and Panofsky 2013; Niewöhner 2011; 2014; Pickersgill et al. 2013). As such, this study is part of a development towards epigenetic epidemiology, which is likely to thrive over the next few years (Davey Smith 2011, 2012). The study is not uncontroversial. Particularly the statistical analysis and peripheral blood as the biological basis for methylation measurement are discussed critically, yet similar studies support the initial findings (Lam et al. 2012, 2013; Suderman et al. 2013). They are interpreted as confirming the idea that 'early life adversity' writes itself into the methylation pattern in a metastable manner.

From my ethnographic work in and with the group, I would like to point out four aspects about this study that do not appear in the published literature, but that are worth considering when trying to better understand how the natural sciences construe processes of differentiation and thus questions of the link between nature and culture:

**(1) Social position is conceptualised in relational terms**

In the group's morning journal and data clubs many discussions evolve around social stratification and how this may affect the body. Part of social stratification is understood in material terms, i.e. measurable aspects of deprivation such as housing or nutrition. Yet many discussions establish a consensus within the group that social position is also about experiencing oneself in relation to other members of society. It is the perception of one's own position in relation to the overall spread of socio-economic means in society that is expected to matter physiologically. The main concern lies with those who suffer from experiencing

that they are positioned towards the lower end of the spread. This is a relational understanding of difference rather than an absolute understanding. The group is not interested in measuring social environments against a normatively or naturally grounded absolute scale. It is about the experience of difference in any given society.

**(2) 'The social' does not exist**

While the group is interested in the effects of social position on human biology, they do not really have a notion of 'the social'. The discussions are – unsurprisingly perhaps – social-theoretically naïve. They reveal an understanding of society as macro structure (socio-economic, politically shaped) that impacts more or less directly on bio-cognitive individuals. 'The social' as an emergent phenomenon *sui generis* in the sense of Durkheim does not feature in internal debate. Instead, socio-economic structures are experienced by individuals and, if anything, social support through family or friends is important as a coping strategy. This is not to say that the individual researchers have no appreciation for lived sociality. Yet they do not operate with theoretical concepts that would give them a handle on different ways of thinking about social processes as part of 'their science'.

**(3) Social position is a pragmatic and insufficient reduction**

The group is very much aware that social position as measured through indicators such as housing and employment status is too simple a measure of processes of differentiation. As indicated above, this does not primarily stem from a thick, social-scientifically informed understanding of lived sociality. Rather it stems from their knowledge about the sensitivity of epigenetic mechanisms. As they discuss repeatedly, even handling the animals during experimentation, i.e. placing them in different cages or allocating them to different mothers in cross-fostering experiments, seems to leave methylation marks sometimes more profound than the actual stressor used in the experiment to demonstrate a particular effect. It is this knowledge about sensitivity, which makes them appreciate that everyday life will produce a constant stream of 'stressors'. The reduction of such complexity to very simple measures of socio-economic status is appreciated as problematic. Yet while they are not necessarily ontological reductionists, who believe that everything starts from and comes down to matter as others in the natural sciences may suggest, they are pragmatic reductionists (Beck and Niewöhner 2006). They are opportunistically scanning the literature and their lifeworlds for useable measures of social differentiation. Epidemiology is the obvious port of call and hence they work with the composite indicator social position. Of course, these

difficulties and debates of translation disappear in publications, when housing and education are treated as *pars pro toto* for social difference.

**(4) Human biology may be local**

When I presented some findings from my lab ethnography back to the group, a discussion around the anthropological notion of local biologies (Lock 1993a, 1993b) arose. It is worth noting that this has been the first group of molecular biologists that I have come across in my work, which appreciated that research on human biology might not only be a matter of going deeper and finer into molecular structures, but might also entail a thicker appreciation of the local contexts within which bodies dwell. I will return to this point in more detail in the final section.

I am not making these points in some detail to paint a somewhat idealised picture of 'my' lab group as particularly enlightened biologists. Neither am I naïve about the dynamics of science funding and practice. Instead I am trying to show how the group grapples with a human biology becoming embedded in social environments – before they purify a narrative for peer-review and publication. The point I am trying to make is that much social science critique approaches such research from a critical distance focusing on illegitimate reductions and biologistic determinisms. Of particular concern have been the biopolitical implications that may be set off by a molecularisation of the social and material environment, effects of mechanistic knowledge of the transmissibility of the manifestations of social difference, a different notion of the body as embedded in multiple spatial and temporal contexts, as well as the consequences for social theory itself. This critique is justified. When concerned with the effects of hegemonic biological discourses on everyday life, it does not make any significant difference what a single lab group is trying to do. What matters is the field of epigenetics' contribution to a specific dispositive and its interpellating consequences for possible and actual subject positions (Epstein 2008). Hence I am not trying to argue that the personal views within the lab group and their 'good intentions' should keep us from criticising knowledge production in epigenetic biology. Yet I want to point out to a presumably largely social scientific readership that this lab group is very much aware of the complicatedness of the issue at hand and that people are willing to enter into discussions about it. They recognise that their research throws up questions that are not easily answered within the existing experimental system. Again: They are pragmatic reductionists, not ontological reductionists (Beck and Niewöhner 2006). Hence, they are prepared to explore new avenues; an opening for collaboration arises. To better understand what this may entail, I will

diffract the life and social scientific perspective, i.e. read them through each other. I begin by exploring some of the established barriers (and their porosity) between life and social sciences against a more productive mutual engagement before outlining 'situating biologies' as a collaborative research programme aimed at addressing material-semiotic differentiation.

## Life scientific perspectives: Treating culture as nature

In an increasing number of life scientific research fields, researchers recognise that they must understand social and cultural phenomena in order to advance their molecular research. Epigenetics is among the most visible, but the social and cultural neurosciences struggle with similar problems (Meloni 2014). Many researchers in the life sciences appreciate that their understanding and use of data on social and cultural phenomena is necessarily limited as the sketch above has shown. The problem is not that biologists imagine society to be simple or that they are pragmatic reductionists. The problem lies in the epistemological and ontological commitments underpinning these life scientific attempts to bridge the great divide. A recent editorial[3] in the journal *Nature* on research on environmental stressors expresses these concerns: 'Many sociologists, however, are still immured in their fortress, struggling to catch up with a debate that has shifted from nature-or-nurture to nature-and-nurture, or are unable to shake off their distrust of scientists, worrying that scientists will force them to play second fiddle in their own territory: the environment' (Nature 2012, 143). From this point of view, the issue of nature and culture is a data problem. The asymmetry of detailed molecular and simplistic social markers arises, because the social sciences do not deliver their share of the data. The editorial seems to suggest that if only the social sciences were up to speed on these matters, questions of the material effects of differentiation could be solved quickly. The epistemological differences between the different epistemic cultures are neither appreciated in this argument nor are they negotiable. It is an implicit assumption that representations of 'the social' will be added to natural scientific representations of the material world – perhaps an unsurprising stance in a natural science journal.

To be fair, the natural sciences do not operate within a singular epistemological framework concerning the link between nature and culture. Bio- and specifically gene-centric approaches are today joined by developmental systems theory, evolutionary developmental biology,

gene culture co-evolution, niche construction theory, research on phenotypical and developmental plasticity and parental effects and, of course, epigenetic inheritance as a matter of transmission of traits through various material, behavioural and environmental routes (see Stotz 2008; Lux and Richter 2014). Yet the vast majority of these frameworks share a belief in a single reality, i.e. an ontological commitment that there is a reality out there that can be represented more or less adequately. Objectifying representations of this reality compete against each other on the basis of their explanatory power derived from a theoretical framework or empirical data or a combination of the two. Nature and culture are operationalised into measurable (quanti- or typifiable) variables. Researchers strive to maximise ecological validity of these variables and the experimental systems with which they are gathered. From a natural science perspective, then, advances in studying phenomena with material and social dimensions are difficult to achieve, because (1) experimental systems that control the increased number of variables are difficult to design; (2) some of the social variables are difficult to control and to reproduce in experiments, i.e. biography; (3) human beings are 'moving targets' (Hacking 2007), that is, they respond (self-)reflexively to new knowledge about them, making modelling human-environment systems a major challenge; (4) the social sciences are not cooperating in studies to deliver sophisticated representations of social phenomena that can be used in biological studies of human/gene environment interaction. The debates in the natural sciences do not appreciate that nature and culture may not be additive. By and large, they treat culture as nature.

## Social scientific perspectives: Narrating the body

The anonymous author of the *Nature* editorial has obviously missed some crucial developments in the social sciences and anthropology. It is true, of course, that biology was declared the enemy of critical thought to defend social and historical analyses against undue tendencies of naturalisation and biological reification (see Tsing 2000). This has been critical particularly as part of the 'academisation' of feminist critique. For radical constructivists, nature has for a long time been text, i.e. the result of historically contingent social, symbolic and discursive practices shaped by the hegemony of specific power/knowledges. It is also true that many areas of the social sciences still understand their research object in purely semiotic or social terms. Yet particularly at the intersections of feminist critique, social and cultural anthropology and science and technology

studies, research over the last 25 years has addressed the body (for example, Scheper-Hughes and Lock 1987), the entanglement of nature and culture in material-semiotic practice (for example, Haraway 1991), the life sciences and molecular biology (for example, Rabinow 1992), and has developed a relational materialism (for example, Barad 1999) that includes a reconceptualisation of 'the social' as in continuous and symmetrical assembly through heterogeneous material-semiotic agencies (for example, Latour 2005). To speak of the social sciences as being immured in their fortresses is missing the point. Yet the editorial hints at a crucial issue that has so far not been addressed in the social sciences and that comes to the fore when discussing the tensions between the two accounts of differentiation as I am doing here: The social sciences continue to *narrate* the material body. They look at it, they ask people how they feel in and with it and they talk and write about it. This is, of course, what social science is all about. Yet if bodies are not only textual performances, but constituted of material and semiotic agencies, do the social sciences need not do more than narrate the body and carefully deconstruct positivist accounts of the material dimensions of the body (Niewöhner and Beck 2017)?

The starting point of this chapter has been the obviousness of the material effects of social differentiation: The man in Northern England sweats. In fact, he says he sweats in an interview after the fact. The study does not address whether he actually sweated, what else changed in his body and whether any of these effects persisted after the event. Few studies in the social sciences do. Bourdieu himself has made the point that the habitus has an important embodied and inert component, which he referred to as hexis after Marcel Mauss' analyses of body techniques (Mauss 1973). So can the social sciences really claim that hexis can be understood by studying it through language and sight only, i.e. interview and direct observation? Or the well-established hysteresis effect, that is, the lingering of an effect after the cause ceases to exist (Bourdieu 1990). Can the social sciences be sure that the social situation in Northern England described above does not set off a hysteresis effect shaped predominantly by somatic continuity in the form of a change in methylation pattern? Praxioscopic methodological regimes are often limited to literally superficial investigations of the body and the narrations of their owners. Material contributions cannot be differentiated, but are reduced to their experiential component as accessible to language (see Niewöhner and Beck 2017). The calls within the social sciences and anthropology are getting louder that this may not

be adequate empirical and analytical treatment for many phenomena involving the human body (Beck and Niewöhner 2006; Lock and Kaufert 2001; Timmermans and Haas 2008).

## Situating biologies: Differentiation as material-semiotic practice

To summarise: I have reported on two cases of studying differentiation in social and material terms. Both cases demonstrate how their approaches point towards the entanglement of material and social dynamics. Yet both cases also demonstrate the inadequacy of engaging the respective 'other' dynamic. In this last section, I want to briefly outline three aspects that need to be addressed when trying to study differentiation as a material-semiotic practice.

First, the starting point of such endeavours should be ontography (Lynch 2013) and an acknowledgement of multiplicity and process ontology. Social and life sciences disagree about the ontological status of the object of research. For the social sciences it is ultimately history and text, for the biologists it is ultimately matter. Common ground needs to be worked out and this work finds a suitable starting point in ontography (Lynch 2013), that is, the ethnographic analysis of the ontological status of the object of research. Here the social sciences have recently produced excellent work, which has culminated in debates about the ontological turn (see Woolgar and Lezaun 2013). At its heart lies the assumption that entities such as diseases or bodies are multiple (for example, Mol 2002). Rather than assuming that entities are singular and stable, various lines of thought within the so-called new materialisms assume practices to be the basic unit of analysis (Dolphijn and Tuin 2012). Entities are made in practices. There is no essence that pre-exists practices. Rather, entities *are* always *how* they are being produced in a specific situated set of practices shaped by the material, political, social, ethical and epistemic dimensions of these practices. The body that is done in a waiting room in Northern England as stressed, sweating and overweight is different from the body that is done in a British epidemiological cohort or a Canadian epigenetic experiment. There is no underlying universal body that is pluralised through different perspectives. Rather, this practice theoretical line of thought always considers knowledge practices world-making practices (Tsing 2010). The boxer's body in Northern England is thus

radically particularised within the specific set of practices in the waiting room where he experiences class differences. It is not a universal body moving into a local social setting. The practice of waiting in a social service waiting room in Northern England in the late twentieth century enacts a particular body.

This turn in the social sciences marks a profound shift from a universal human biology to a radically particularised human biology. It begins to take seriously the material body and its role in social differentiation. It offers an ontological shift that potentially enables a different engagement with the natural sciences. Most research in this vein, however, has focused on demonstrating how in sets of practices bodies are made multiple, i.e. particular. Little research has focused on the question whether and how the material body may resist this radical particularisation. What if this experience of social difference materialises in metastable epigenetic changes? The differentially methylated material body may carry significant continuities through widely different sets of practices. This does not challenge 'the body multiple' in principle. Yet in practice, 'reality may kick back' in contributing to a very stable body across practices. For example, sweating in situations perceived as stressful – 'caused' in material terms by a sensitive biological stress axis – can quickly attain symbolic qualities and carry social meaning, for example, signal insecurity and non-belonging. Bourdieu discusses in speculative theoretical terms how people are unable to become habituated to very different milieux; an experience he himself certainly made countless times during his meteoric rise through the French academic intelligentsia. He does not explore the role of the hypothalamic-pituitary-adrenal axis in this context – but he should have. The point here is not to naturalise the effects of social differentiation and introduce biodeterminism through the backdoor. Social differentiation does not determine methylation patterns thus reifying them. Rather, human practices of differentiation (see Hirschauer 2014) entangle material and social dimensions. The question what is local and particular and what is universal about the body in practice has not been addressed properly by the social sciences (see Lock, this volume). The question has become a legitimate question for social inquiry through recent theoretical advances. Yet this newly found theoretical space needs to be explored empirically and with open minds on all sides.

The epigenetics researchers in the lab investigated in this study apparently appreciate that bodies may be particularised through their embedding in local practices. They appreciate 'local biologies' in principle (Lock 1993a, 1993b and this volume). Essentially, they argue for a pragmatic approach. If everything is locally specific, the right level of understanding

to intervene into the body needs to be determined. Ontologically, this position entails a body with a universal material core and increasingly locally specific epiphenomena draped around it. It is a position more akin to gene–environment interaction than to the body multiple or local biologies. Within the philosophy of biology, however, recent work has proposed a process ontology for biology (Dupré 2014). Rather than starting from an essentially Aristotelian perspective wondering about the essence of biological entities, biology ought to consider its object of research in process terms, asking what organises continuity and operational closure over time. Epigenetics research with its analytical sensitivity for different temporal and spatial contexts is very open to such a process ontology; after all the question of transgenerational inheritance is fundamentally one of process and continuity; so are questions about *de novo* (de)methylation in reaction to environmental changes. Yet epigenetic research in practice is driven by experimental design and does not spend much time thinking about the ontological status of its object of research. It therefore misses the opening offered by a process ontology and the opportunity to integrate social dynamics into the study of material phenomena.

Secondly, biologies need to be considered as situated. The introduction to this volume sets out the notion of the biosocial as a recent social scientific and anthropological concept that enables the search for a reconfiguration of nature–culture relations. Combined with Deleuzian thinking about 'becoming' as the rhizomatic dynamic of human life and personhood, the editors propose a very productive notion of biosocial becomings as a way of thinking about trajectories of growth, movement and learning rather than interacting entities with stable and fixed identities (Ingold 2010). Affinities with a process ontology and also with the multiplicity of bodies are strong. I am very sympathetic to this position, but I fear that it is rather inaccessible. Its language is difficult to understand for non-social scientists and it is not easily operationalised, particularly not in cooperation with biologists.

Also, in response to anonymous reviewers of this chapter, I want to try and stay away from unnecessary terminology and outline two approaches that I believe could facilitate an empirical and analytical attentiveness to biosocial becomings, i.e. the continuous entanglement of matter and meaning in practices of human differentiation.

A first approach is offered by ecosocial theory and the notion of the emergent embodied phenotype (Krieger 2012). Public health scholar Krieger argues that bodies express the ecology within which they dwell over time. Specific phenotypes emerge in reaction to ecological conditions, a complex process of embodiment itself situated within

evolutionary, social, biographical and cellular time or history; sometimes referred to as *eco-evo-devo* (Gilbert et al. 2015). Compared to standard measures of socio-economic position as used within environmental epigenetics, ecosocial theory offers a more fine-grained set of indicators and it embeds these indicators in social contexts, for example, community or neighbourhood effects, as well as historical developments and political contexts. Particularly in the area of social inequality and health, this is a very promising approach that has also begun to explore the relevance of epigenetic findings (Davey Smith 2011, 2012). The emergent embodied phenotype appreciates the processual nature of material and social entanglement. Yet it remains true to a quantitative indicator-based approach that is epidemiological in kind and that is easily appreciated by molecular biology. For the Northern England case, an ecosocial approach would identify the middle-aged boxer as a member of a particular milieu and then try to describe and analyse the social and material dimensions of this milieu that may have become embodied in the boxer's phenotype over time – always also considering the political and economic circumstances that shape these environments as well as the dominant knowledge practices that shape risk factors, diagnostic tools and data availability (see also Aronowitz 2008). This approach would also include further biological samples and epigenetic analyses of members of the particular milieu, possibly comparatively against maximally different milieux or similar milieux in different settings.

This approach offers a high use value in the field. Yet it works best where milieux or social groups in general can be defined in a reasonably straightforward manner at a meso-level based on appropriate sampling techniques. For the US context, as the Chicago School already showed for cities in the first half of the twentieth century, group divisions between race and class tend to correspond with living conditions and location within urban spaces. This means that housing conditions and access to infrastructure and amenities tend to correlate highly with social milieu. Also, a health and welfare system that – compared to Western European countries – values private contributions highly, also stratifies access to healthcare and welfare along socio-economic lines, including its consequences for health outcomes. In other contexts, particularly within cities, milieux or other meso-scale groupings are much more difficult to discern.

A second approach would start from the micro-level. We started to develop this approach in the context of the cultural neurosciences, where simple notions of culture (for example, Western versus Chinese or Arabic) were leading to problematic ascriptions of difference. Rather than starting with preconceived notions of difference or indicator-based

groups, we thus suggested to start from long-term ethnographic research aimed at discerning patterns of differentiating practices (Roepstorff et al. 2010). I have discussed the notion of customary biology elsewhere, i.e. a biology based on regularities of everyday practice rather than natural laws (Niewöhner 2011). The basic idea here is that people use their bodies in particular, habituated ways and that in twenty-first-century urban contexts, these 'customary' ways of conducting the body are not necessarily tied to traditional socio-economic milieu or class. Human differentiation in, for example, Western European cities has become highly dynamic both situationally and biographically, and often a matter of performance and style. The balance between situational and dispositional factors in shaping urban everyday life has shifted towards the situational, challenging established sets of indicators and sampling techniques in epidemiology and quantitative social science. Hence the second approach starts from the thick ethnographic record of social differentiation in different locales, its political, historical and economic drivers, and its stabilities and discontinuities, to identify contexts that would warrant closer attention. A first inductive ethnographic approach to understanding differentiation in everyday practice in a particular set of people would lead to an identification of patterns that could be correlated with biomarkers in order to generalise and compare: an abductive inference. Biomarkers should attend to stress response on different levels of analysis: from situational markers such as cortisol in saliva or skin conductance to methylation state for metastable, i.e. rather more dispositional, effects. Longitudinal designs are paramount. Finding valid proxies and minimally invasive and mobile methods for measuring these markers will be a challenge. Such an approach (see Timmermans and Haas 2008) would not only situate biological bodies (bios) within very specific patterns of everyday practice. It would also need to situate its own knowledge practices (bio-*logos*) to be able to systematically reflect reductions inherent in any such studies. Experiences with such inductive-abductive approaches including biomarkers are as yet absent, largely because longitudinal studies in the qualitative social sciences are rare and the expertise for biomarker measurement is absent, necessitating cooperation.

A third approach, which sits somewhere in between the two approaches sketched here, might draw on field sites that exhibit characteristics close to a natural experiment, i.e. clearly defined exposure of a population to a well-known 'stressor'. Examples of such approaches include malnutrition during the Dutch Hunger Winter in the 1940s, the use of Agent Orange in the Vietnam War, or early-life adversity in Romanian orphanages towards the end of the Ceausescu regime (see

Lock, this volume; Niewöhner and Lock 2018). Yet whether such retrospective analyses lead to thin simplifications or are able to produce a thick analysis of material-semiotic differentiation depends first and foremost on the analytical lens and data availability.

Third and lastly, different forms of collaborative research are needed to situate biologies. Biology needs to be situated in two ways. Firstly, and this has hopefully become clear in this chapter, bodies-in-action become situated, i.e. particularised through specific practices that are in themselves shaped by history, politics and ethics. The dynamics of use and particularisation may be very local, for example, in cases of war or environmental catastrophe. Yet increasingly they are dispersed across the globe, marked by phenomena such as migration or the distribution of infectious disease agents (Niewöhner and Lock 2018). Secondly, biologies are shaped by the way they are known and produced through knowledge practices. Knowledge practices are, of course, always situated in particular epistemic cultures and broader societal contexts. As Haraway has pointed out, knowledge practices are also always partial, both in the sense of biased and incompletely related (Haraway 1988). These two dimensions of situating biologies need to be studied as interdependent.

Situating biologies is a co-laborative agenda (Niewöhner 2015, 2016). It is about temporary joint epistemic work between anthropology and biology: Reading together, designing studies together, conducting experiments and fieldwork together, writing together. Anthropologists and biologists need to treat each other in a parasici manner, i.e. in a mode of 'doing theory in continuous relation to the distinctly non-"meta" immersive quality of thinking during fieldwork' (Deeb and Marcus 2011, 68; Marcus 2000, 2001), as technicians of general ideas (Rabinow et al. 2008) rather than as observer and informant. The aim is not a shared, collaborative goal or objective of explaining differentiation more fully. The aim is to produce epistemic momentum and different kinds of reflexivity in order to make participants think differently (Boyer 2015). Des Fitzgerald and Felicity Callard speak of experimental entanglement. 'Experimental entanglements are modest, often awkward, typically unequal encounters that work to mobilise specific and often serendipitous moments of potential novelty in and outside the laboratory'. They 'refuse preliminary decisions about the shape or outcome of such an interaction […], denote an ad hoc process of shuffling histories, methods, and assumptions [and] are thus never not temporary, local assemblages of motivation, interest, people and machinery – in which we, and our collaborators, are able momentarily to think something exterior to both the conventions of experimental practice, and the taken-for-granted

dynamics of epistemic power that underwrite its conduct' (Fitzgerald and Callard 2014, 18).

One might follow Roepstorff and colleagues in understanding experimentation as a particular aesthetic of research practice, i.e. a commitment to working together while retaining epistemic openness and the willingness to pursue emerging trajectories (Roepstorff and Frith 2012). In this broader sense, situating biologies is not only about lab work, but it is also about other kinds of fieldwork that might bring biologists into situations that they find good to think with. Hence successful co-laboration on material-semiotic differentiation will not result in comprehensive theory or the ultimate experimental study. It could produce findings that anthropologists might take back into the disciplinary heart of anthropology to ask questions about the treatment of materiality in social inquiry, about the sources of stability in the reproduction of social inequalities, and about the conceptualisation of the relations in bodies-in-environments. It might also produce findings that biologists will take back to their discussions about the embeddedness of gene regulation in different contexts, about the organism as a unit of analysis in evolution and development, or about the human body as usefully thought of as something always *in use*.

## In conclusion: Appreciating biological regularities

*Situating biologies* is a research agenda concerned with the analysis of practices of human differentiation, or, more generally, practices that promote human differentiation in interesting or problematic ways. It questions the stability (or not) of material-semiotic practices without privileging material or semiotic aspects *a priori*. It inquires into the human body *in action* and asks how it might usefully be considered local or universal and with what kind of consequences. Situating biologies asks of anthropology to stop considering biology the enemy of critical thought. And it asks of biology to be open to the idea that bodies in action may be more productively described, analysed and indeed interpreted in terms of regularities rather than laws. As historian of science Lorraine Daston demonstrates, natural and moral orders shift from custom- to law-based systems during the Enlightenment and the rise of the nation state in early modern Europe (Daston 2002). Until then, knowledge about natural processes and moral orders is largely based on regularities. Processes of habituation, of custom formation and of patterning of everyday practices are deeply embodied processes. Or: Bodies are being used in social action, meaning-making and everyday life. Such usage forms patterns and regularities. While

natural laws 'naturally' also apply to these patterns, they may not be the most useful language of description and analysis. The social and historical contingencies and the reflexivities of material-semiotic practices produce complexities that are hard to model in law-based approaches. Situating biologies offers the opportunity to appreciate regularities.

A word of caution in closing: In advocating situating biologies as an agenda for anthropology and biology *together*, I may have given the impression that the two may join in new comprehensive theories of embodied social action and human differentiation. This may be the case. More likely, however, is a scenario where anthropologists and biologists working on situating biologies will not readily come together, but instead find joint research intensely irritating. It is likely that their analytical sensitivities will not readily match onto each other, but rather produce *Widerstandsaviso* (Fleck 1935) for the respective 'other'. Such thought constraints could be highly productive and generative even if they do not lead to a grand synthesis of biological and social theory.

## Notes

1. I use the term 'affords' or 'affordance' (Gibson 1977) deliberately. This environmental psychological notion suggests that the environment contains clues or suggestions, so called affordances, to social actors how to act *with* that environment. A frying pan is fry-withable. It does not suggest itself to be used for knitting.
2. The phenomenon of transmission of epigenetic states is well known in plants as well as animals. Yet studies that have tried to show chemical stability through the germ line, i.e. transgenerational inheritance as conceived in genetics, have failed to produce positive findings. In controlled environments, the first generation that has not been exposed to the experimental stressor reverts back to the original epigenetic patterning (Waterland et al. 2007). Other paths and modes of transgenerational transmission of epigenetic patterns, also involving gametes, have been discussed and shown experimentally (see Daxinger and Whitelaw 2010, 2012). More recently, paternal routes have also received attention after research had focused almost exclusively on maternal lines (Soubry et al. 2014). Yet the mechanisms that may transport epigenetic patterns through the re-setting machinery of meiotic division remain elusive to date. Recent research is beginning to focus on RNA biology and on cis/trans effects, i.e. effects that are mediated via extra-nuclear routes and agents. While not new in principle, this adds another layer of complexity to the field and it is entirely unclear whether the puzzle of transgenerational stability will be solved at the level of mechanism any time soon. Most likely, perhaps, the question will shift from a dichotomous 'yes/no' to a more differentiated 'how important' is what form of transgenerational epigenetic transmission in what contexts (for example, Grossniklaus et al. 2013).
3. Following a reviewer comment, I attempted to find out the name of the author(s) responsible for the editorial, but failed to do so. It is published in the journal anonymously.

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Chapter 3

# Pig–Human Relations in Neonatology: Knowing and Unknowing in a Multi-Species Collaborative

Mette N. Svendsen

## Translating pigs into human health

'Okay, so we are your piglets?' some of the researchers in a pig facility at the University of Copenhagen teasingly asked my graduate student Mie S. Dam and me in 2014. Since 2009, I had followed them in their experimental practices of making piglets into models of human infants to advance nutrition and health for prematurely born infants in the neonatal intensive care unit (NICU). I conducted fieldwork in their pig laboratory, at scientific seminars and conferences, and in the human NICU at the University Hospital. The comments about the researchers being 'our pigs' put on equal footings the researchers as resources in our knowledge production and the piglets as resources in theirs. To me, it raised questions about how something or someone becomes a resource and it brought into view the ways in which resource-imagining and resource-making were at the heart of both social science and natural science. In this chapter, I critically assess the conditions that facilitate the appropriation of the pig as a resource for human health and the foregrounding and backgrounding of what is acknowledged about this appropriation when the bench and the bedside are brought together within the same research framework. I end with a short discussion of the cultural knowledge made possible in the multi-species and multi-disciplinary collaborative in which the researchers could jokingly figure as 'our pigs'.

In the introduction to their edited volume, *Timely Assets*, Elizabeth E. Ferry and Mandana E. Limbert state that although we may see stone, forest or livestock as obvious resources, nothing is intrinsically or self-evidently

a resource (Ferry and Limbert 2008a). Rather, the concept of resource entails 'ideas of the world as available for human use, and of that use as the basis of proper human society' (Ferry and Limbert 2008b, 8). This also implies that the Euro-American notion of resource presupposes a separation between human exploiters and the 'nature' exploited (Ferry 2008, 52). Anthropological scholarship from different parts of the world illuminates that resources are not conceived in the same way everywhere. In hunter-gatherer societies in different parts of the world, relationships between humans and hunted animals are lived as long-term social relationships and forms of kinship (Conklin 2001; Nadasdy 2008; Willerslev 2007).

In the following text, I am particularly interested in how resource-making is practised in the administration of life and death in Danish translational medicine and what notions of the 'proper' human society come to the fore. How does resource-making, which in the laboratory is closely linked to making (pig) life and death, carry moral reasoning and future orientations? How is the pig as a proxy for the human presented when bringing the animal resource out of the laboratory? How is the value of life negotiated in managing limited resources in the neonatal intensive care unit?

To answer these questions I draw on my fieldwork in three sites that are part of the infrastructure of translating pigs into human health: The pig laboratory in which premature piglets are put in incubators, taken care of and eventually killed to become valuable samples in paediatric gastroenterology research; the semi-public spaces of scientific conferences in which pig-based research is presented to various actors in the field of translational medicine; and the human NICU where preterm infants or seriously ill term infants are treated and where resource scarcity and resource imagination also enter into life-and-death decisions. I investigate the various forms of unknowing that, for good reasons, the researchers and clinicians engage in, and argue that such unknowing is part of a complex boundary work that upholds existential inequalities between human and pig, and existential equalities between human infants. I begin with a short introduction to the broader landscape of appropriating the pig in Denmark.

## Imagining and claiming pigs as resources for health

For centuries, the welfare of the Danish population has largely relied on claiming the pig and other livestock as a resource for humans and breeding it for food. Breeding practices have been based on systematic selection

and have resulted in the 'local biology' (Lock 2001) of the famous Danish pig with leaner meat, an extra rib and large litters. While the Danish population is less than 6 million people, the number of pigs produced per year amounts to approximately 26 million. This number is the result of a huge scaling-up of pig production in the mid-twentieth century and illuminates the pig as a 'world-defining creature' (Blanchette 2015, 648) shaping the Danish landscape and its economy as agribusiness, providing a sizeable portion of the state's income, and thereby contributing considerably to the welfare of the general population. Put differently, a shaping of pig lives and bodies on the one hand and the creation of welfare and health of Danes on the other has continuously taken place. While many Danes are ambivalent about the precarious pig lives in pig production and the pollution of Danish waters due to discharge of slurry from pig farms, pork is still a staple diet of most Danes and pigs are considered mundane production animals that contribute to a familiar fabric of living. In many ways, the pig occupies the same role in the Danish cultural and political economy as the sheep in the UK (Franklin 2007), salmon in Norway (Lien 2015) and cows in the Netherlands (Taussig 2004).

Within the Danish agricultural field, the Danish pig breeding programme is seen as a national achievement and a treasure to be protected, yet the large litters of the Danish sows have also resulted in rearing problems. Often the sow does not have enough teats to accommodate the entire litter and piglets are born less mature, a circumstance that might be related to the lean tissue growth and the large litter size (Sangild et al. 2013). The litter hierarchy, which is established within the first day after birth, leaves the weaker piglets either without access to colostrum, the highly nutrient-rich first milk after birth, or with access to only the low-quality colostrum of the back teats (Bollen et al. 2010, 9). Due to their weak condition, hypothermia and poor access to milk, 25,000 newborn piglets die every day in Denmark (9 million every year). The high mortality in the farrow stables, which is a general problem of intensified pig production, has been frequently discussed in both the agricultural field and the daily press in Denmark, and research has been initiated and solutions developed such as better feed products and heating for the newborn piglets. One of the feeding solutions comes from a small company in Southwest Denmark that has developed a milk product consisting of whole bovine colostrum. The bovine colostrum is collected from dairy farms in Denmark and subsequently homogenised, pasteurised, spray-dried and turned into a powder easily dissolvable in water, and administered at the pig farms.

At the other end of Denmark, at the University of Copenhagen, the immature piglets of the large litters and the bovine colostrum product have become central in imagining and claiming Danish pigs as resources for infant health globally. At the University of Copenhagen, the researchers I collaborate with have studied paediatric gastroenterology for the last 20 years using the Danish pig as a model. They find the local biology of the immature piglets from Danish food-production to be excellent models of weak infants at risk of the devastating and life-threatening inflammation of the gut, necrotising enterocolitis (NEC), which is said to occur in 7 per cent of infants with a birth weight between 500 and 1500 g (Neu and Walker 2011). During their studies of the etiology and prevention of NEC, the group has developed a laboratory procedure in which piglets are removed prematurely by surgery (C-section), put in incubators, and provided with different forms of nutrition (for example, infant formula, bovine colostrum, human donor milk). The piglets come to develop NEC during the first 5 days, after which they are killed and their organs, especially the intestines, sampled and analysed. Some of the group's most promising experiments show that the bovine colostrum product from the Danish company is as effective as human donor milk in protecting against NEC and is superior to both human donor milk and infant formula in stimulating growth, gut immunity and digestive functions in premature piglets (Jensen et al. 2013; Rasmussen et al. 2016).

To the researchers, their studies also indicate that the bovine colostrum product will have a positive effect on infants deprived of mother's milk, a situation common in NICUs where premature birth makes it difficult to stimulate milk production and where breast-feeding often becomes challenging, leading to premature infants depending on formula or human donor milk. Thus, their hypothesis is that in premature infant feeding, bovine colostrum may be superior to infant formula, and maybe also to human donor milk. Based on similarities between preterm piglets and preterm infants with respect to size and the impaired respiratory, nutritional, immunological and metabolic responses after preterm birth, they envision a translational process in which the piglet literally stands in for the infant. The group in Copenhagen does not stand alone in their preference for pigs. Within the global scientific community, the recognition of important phenotypic and genotypic traits between humans and pigs has been central to the increasing use of pigs in biomedical research and the great interest in pig-to-human transplantation (Gutierrez et al. 2015). While such cross-species transplantations still prove difficult, the pig continues to provide a highly useful model of the human organism in a broad range of biomedical research (Groenen et al. 2012; Kuzmuk and Schook 2011; Swindle et al. 2012).

To realise the translational potential of using preterm pigs in gastroenterology research, the professor in charge of the pig laboratory received a prestigious grant from the Danish state in 2012 to establish a research platform, NEOMUNE, in which studies in piglets and mice are to be coupled with observational and clinical studies in NICUs in a number of countries. The vision of NEOMUNE is to develop new diet and microbiota treatments for normal and compromised newborn infants; and to establish adequate universally accepted clinical care procedures for infants with limited maternal care – an objective that embodies the idea of a universal infant biology to be administered by universal clinical care procedures. By collaborating with scientific and clinical partners from different countries as well as dairy companies, NEOMUNE incorporates the whole process from laboratory studies through clinical studies to marketable nutrition products commercially sold to NICUs/parents globally. NEOMUNE also includes a small social science study which examines the ethical, social and cultural aspects of translating across bench (the experimental pig studies) and bedside (clinical practices in the NICU). Heading this study, I – together with graduate student Mie S. Dam – have become part of the NEOMUNE team following and collaborating with the researchers and clinicians involved in taking care of piglets, data and infants.

In the clinical studies which are being initiated, clinicians in NICUs in China and in Denmark will ask parents to consent to feeding their preterm infants a refined bovine colostrum product approved for humans from the Danish company as part of investigating and documenting the efficacy of this nutrition in infants devoid of breast-feeding. Thereby the Danish piglets are seen as a central actor in paving the way for bovine colostrum to reach the stomachs of infants worldwide, and in bringing together scientists, industrial partners and clinicians from around the world. A powerful vision of optimising infant health globally through crossing geographical, cultural, disciplinary and species-related boundaries is at the core of articulating the pig as a resource for human infant health.

The realisation of this vision is highly dependent on connecting the locally produced colostrum product to the Danish piglets in the laboratory, and to clinicians, parents and infants in NICUs in China and Denmark. As the research director explained in an interview with my graduate student Mie S. Dam and myself in 2013: 'If one day the Danish company is not here, the colostrum project will end, because I need to have someone to make the irradiation [of the colostrum] and do the testing and so on […] and to know how to pack the substance and to secure a sterile

product [for the clinical studies].' In other words, a long local tradition of appropriating Danish pigs and cows and turning their substances and lives into human welfare is inseparable from claiming pigs as resources for infant health globally. The history of the local biology of the Danish pigs (large litters, lean tissue growth) and the locally developed solutions to prevent the high death-toll in the farrowing stables (the administering of bovine colostrum), are hardly visible in the research objectives of 'identifying milk and microbiota treatments through infant and animal studies'. However, Danish pig history and local solutions to piglet deaths are pivotal to imagining the piglet as a resource for infant health, and transmuting it into something completely other than a production animal – namely into a platform for developing scientific breakthroughs that will put NEOMUNE on the map of prestigious science, optimise infant health, and create promising business for dairy companies. To follow how the local is woven into promises of global connections and universal knowledge, I now turn to the first step of the research process: enrolling Danish piglets into the laboratory.

## Making resources in the laboratory

It is early Monday morning and the sow, from a farm outside Copenhagen, lies anaesthetised on the table in the operating theatre surrounded by professors, graduate students, animal technicians and master's students who each have specific tasks to do in relation to the C-section that is about to take place.[1] The atmosphere is relaxed. Some of the students talk about the parties from the weekend just passed, and a graduate student asks everyone to take part in a guessing game about the number of piglets to be delivered. The quantity of the resource is of interest to everyone. For the master's students, the C-section is part of their surgical training and hence the sow an educational resource. Standing next to them I follow how one piglet after the other is carefully lifted out of the large body and handed over to the graduate students who start ventilating the piglets and then moving them to a separate room where they are placed in heated, ventilated, humidified and oxygenated individual incubators. Twenty piglets in total are taken out of the womb. A group of both senior and junior researchers begin the work of providing each piglet with an identifying letter, determining their sex, weighing them, taking their temperatures, and putting all the data into the computer. They also insert catheters into the piglets and connect them to individual nutrition machines by which they will be fed during the study. The researchers'

determined and routinised work on connecting the nutrition machines to the anaesthetised piglets' limp bodies underlines the piglets as unspecified 'gut units' to be turned into scientific tools for creating viable lives in the NICU. In other words, biological (and killable) pig bodies are projected onto biographical and (liveable) infant futures. The first step of this process is accomplished by enclosing the piglets in the laboratory, carefully following the protocol that is patterned after procedures in the NICU; and on the last day of the experiment by turning them into samples to be processed and analysed with the aim of gaining new insights into the critical neonatal period.

Daily laboratory practices in the following days, however, illuminate a much greater complexity. When the piglets wake up from the anaesthesia, they gradually gain individuality and in the days following the C-section, some of them become sick and suffer (for example, from respiratory distress). A team of four or five graduate students attend to the piglets with meticulous care day and night. Such care work in animal laboratories plays a constitutive role in the organisation of the experimental practice and shapes the animal bodies and the findings that result from them (Friese 2013). In the Danish laboratory, the piglets are not only enacted as unspecified guts that react to microbiota, but as sentient lives placed in relationships to the researchers who feed them individually, change their nappy-like cloths, and demonstrate great efforts to reduce their sufferings (Svendsen and Koch 2013). These exchanges between human researcher and research animal take place in small and ordinary interactions, as when the animal technician attends to a piglet that is not thriving and unwittingly pats her own stomach, saying, 'Its stomach-ache sure must be painful.' In such situations a kind of existential affinity – even kinship (see Dam et al. 2017) – between human and animal appears, thus contesting a strict separation between 'human exploiters' and 'exploited resources'. Similarity and difference cannot be neatly determined, but go together (see Mol and Law 1994).

In the autumn of 2013, the group initiated a set of new studies that investigated how nutrition affects brain development. The cognitive development of the pigs was tested through 26 days. While the standard preterm model runs 5 days, it was a huge expansion to let the sometimes severely compromised piglets live for more than 20 days in the laboratory. In these experiments, the individual monitoring of the piglets had become essential to ensure the survival of as many as possible until day 26. While euthanasia sometimes, perhaps, seemed the most benevolent act towards the individual suffering piglet, the researchers

were painfully aware of the dilemmas of this act as they opted for statistically significant results and hence needed a certain number of piglets to survive to day 26. As I have heard numerous times in conversations in the lab, 'a euthanised piglet costs a piglet at the other end' (*det koster en gris i den anden ende*). 'The other end' refers to the monetary costs of enrolling one more litter into the laboratory, the laborious and time-consuming work of running the study, and the suffering of these future piglets that substitute the euthanised ones. Thereby 'the other end' points to the landscape of knowledge production of which the researchers are part, and the pressure on them to reach scientific results, to stick to the project plan and to complete graduate studies within timeframes settled by the grant proposals. Here the issue of scarcity, so integral to conceptualising something as a resource (Ferry and Limbert 2008b, 7), was not imagined as a possible depletion of pigs in Denmark, but experienced as a limit in terms of money, work and suffering.

In a group conversation about this issue that graduate student Mie S. Dam and I set up in June 2013, one postdoctoral researcher said: 'The pig is a valuable resource. We don't want it to die [before the scheduled time]. But [on the other hand] our individual treatment may also prolong suffering. So what is ethics here?' It is important to note that 'ethics here' does not refer to animal ethics as understood within a bioethical framework of institutionalised rules and guidelines of professional conduct. In all their practices, the researchers carefully follow bioethical codes of conduct. By asking the question 'what is ethics here?' the postdoctoral researcher alluded to the 'ethics' that in spite of numerous guidelines will always have to be lived through one's own body and sensations and is situated 'here' in specific spaces and interactions that are unique. In other words, she hinted at the moral peril (Mattingly 2014, 15) that each experiment holds.

Her question also highlights that claims about resources are not only acts that engage morality, but also time (Ferry and Limbert 2008a; Sharp 2014). As Ferry and Limbert state, 'to define something as a resource is to suspend it between a past "source" and a future "product"' (Ferry and Limbert 2008b, 6). In handling highly compromised piglets and in the end killing them to create samples for their research, the researchers invested their working lives in transforming the *source* of production pigs in Denmark into the future *product* of 'optimal care and diet for newborn infants'. To the researchers in the laboratory, this work continuously raised questions about what is 'good'. The same postdoctoral researcher explained in the group conversation.

> This morning I saw a poster that said: 'Most mice die because of wrinkles'. It was an ad against using mice in the cosmetics industry. Thinking about this ad I realised that to me it makes a huge difference that I work with animals for the sake of the clinic. I can't say that I will never work for the cosmetics industry, but I would definitely have great difficulties working with animals for cosmetics.

While her story hinted at the presence of moral questions and vulnerabilities in the laboratory, her statement about doing it 'for the sake of the clinic' placed the hard work of appropriating the piglets' lives and death in a temporal horizon and imbued it with the value of human becoming and notions of generativity. In the context of the NEOMUNE research platform, this future-making of optimising infant health was inextricably linked to creating knowledge in collaboration with NICUs in the global field, generating continuous funding for research, and promoting economic growth to the nation through collaborating with small as well as giant players in agribusiness. In bioscience, such scale-up through industry collaboration and clinical trials has proved increasingly challenging, illustrating that moving an invention into therapeutic use is much harder than making the discovery (Fischer 2010). In the following text, I trace the work it takes to bring the pig studies out of the lab, connect them to numerous actors in the field of translational neonatology research and thereby have the Danish pigs tie together science, health and capital.

## Bringing the pig-based resources out of the laboratory

At the end of every experiment, the researchers began the work of analysing samples and turning them into written papers. Simultaneously with writing up papers, they presented their results at research seminars in which the various partners of the research platform were brought together. Here laboratory researchers, clinicians from NICUs in the Netherlands, England, New Zealand, Australia, China and Denmark, and researchers and representatives from the industry, discussed how to connect and align experimental animal studies and clinical studies and how the various studies may be of interest to the industrial partners. In participating in these meetings, I noticed that the presenters of the pig studies sometimes started out with a statement like: 'We can do things on animals that we cannot do on human beings.' Such introductory comments situated the experiments in the moral economy of animal-based science according to which the management of the animal's life and death ('do

things on animals') was legitimised by the moral difference between human and animal ('that we cannot do on humans'). Apart from such comments, the presentations were usually silent about the hard work of caring for individual animals on a day-to-day basis, which shaped in profound ways the experimental practice. The piglets appeared in the form of precious graphs and numbers, and were discussed in the language of medical categories such as 'gut microbiota', 'neuro-endocrine signalling', or simply 'metabolism'. The overall framework of these presentations was the enthusiasm of creating path-breaking knowledge and new infant diets and microbiota treatments for the NICU. The piglets constituted 'evidence', and the caregiving and death through which this evidence was produced was not considered relevant to be included in the limited time of scientific presentations, and thus remained untold and unknown.

In her book on moral thinking in the experimental worlds of xenotransplantation and mechanical hearts, L. Sharp argues that erasing subjective properties of individual animal or human bodies silences moral questions related to experimentation (Sharp 2014, 44–6). Similarly, S. Lochlann Jain's study of the mortality effect in randomised control trials (RCTs) in oncology powerfully illuminates that the RCTs' future thinking, hope, and strong notion of progress result in the obfuscation of suffering and death, to which she refers as the 'ghosting of lives' (Jain 2010, 90). Among social scientists, such ignorance or unknowing of, for instance, suffering and death does not represent a lack of knowledge, but rather constitutes a form of knowledge that is out of place and therefore may pollute organisational principles and make it difficult for organisations to function and pursue their goals (Geissler 2013; Marris et al. 2014; Rayner 2012; Mathews 2011). For example, in his study of the production of medical knowledge in transnational clinical trials in an African city, Wenzel Geissler (2013) illuminates how research staff's knowledge of research subjects' hunger and lack of healthcare was central to making the clinical trial function on a daily basis (sharing food with research subjects, convincing them to join and stay in a trial), yet all this knowledge did not constitute 'data' and was excluded from scientific reports. This exclusion also contributed to upholding research participation as based on voluntary participation and equal relations between research staff and trial subjects and adhering to scientific conventions according to which hunger belonged to a background factor outside the focus of research (Geissler 2013, 18–20). In drawing attention to the dynamics of constructing knowledge and ignorance differently over time and across various arenas, Geissler's study points to the ways in which professionals' oscillation between knowing and unknowing

productively links bodies, lives and institutions in scientific knowledge production, thereby creating the much-valued biomedical knowledge that may improve health.

While the unknowing that Geissler identifies pertains to material *inequalities* between research subjects and researchers, and between institutions involved in transnational clinical trials, the unknowing present in experimental animal-based science pertains to the animals as sentient and qualified lives, what we may think of as existential *equalities* between human and animal. Consequently, what the researchers in the animal facility seem to engage in when moving between different spaces in translational medicine is a sophisticated switching between knowing the piglet as a sentient being in the experimental practice and excluding this dimension at scientific meetings, in scientific papers and in reports to the media. This differentiation between places may be approached as not simply an *exclusion* of particular aspects of practice so as to maintain boundaries of legitimate knowledge, but also as an *inclusion* of important aspects of practice (see Geissler 2013, 15) as part of scaling up. The inclusion of treating piglets as unspecific biology in scientific presentations makes the researchers adhere to ideals of standardisation, detachment and reproducibility in the biological and biomedical sciences, thereby paving the way for the clinical studies by creating easily exchangeable and recognisable knowledge within the scientific community. The simultaneous exclusion or erasure of the specificity of the local pig biology and the local practices in the laboratory facilitated the piglets' attachment to new (complex) phenomena such as clinical studies and future clinical trials. We might see the research presentations as a way by which the interdisciplinary research group made their work accountable to each other and grounded it in a promise of future translation (see Brosnan and Michael 2014, 695). They took responsibility for realising the aim of translation by making their studies understandable within collective discussions of identifying the optimal time, amount and composition of nutrition to neonatal infants at risk of NEC. In these discussions, the scientists simply did not see their interactions with the piglets and all the care work as crucial for the scientific quality of their research. As much as they depended on this non-scalable care practice to create good data, they also relied on ignoring it as part of scaling up their studies and pursuing the next step of clinical studies and the future step of clinical trials.

On several occasions I discussed with the director of NEOMUNE the question of what can be known publicly. In an interview with myself and graduate student Mie S. Dam, he reflected upon the possibility of using photographs when informing non-scientific audiences of their research.

> NEOMUNE director: Photos are part of the reality, yes, but only a small part. It is a bit like, I don't know if this comparison will work, but it is a bit like exposing [human] bodies, naked bodies. This is a way of exposing a human being, but we don't think that this [exposition] *is* the human being […]. In the same way, if we expose the newborn piglets too much … there are many feelings connected to the newborn and especially there are many feelings connected to suffering and illness. I think it is a little similar to the photos of hungry children from the developing world. We usually sense that there is something almost damaging in exposing [such photos] too much, because you flatten what you want to show. Also because you become immune to it. There are some things in life which are important, which are central, we should be careful not to expose them too much in pictures and films because then they will lose their …
>
> Mette: Almost their dignity?
>
> Director: Yes. Their dignity, and this is why I'm a little worried about giving the public a wrong and twisted impression of what we are working with, but there is no part of our research which is secret […]. The way I may best explain it is to say that it is very sensitive and dignified and you shouldn't expose it too much.

This conversation about respecting the dignity and worth of the piglet and the research practice it is part of, provides a glimpse into the world of many publics that the research director and his team navigate. His considerations are not necessarily different from those of clinical scientists who are also careful about how they talk about research subjects who may also be terminally ill patients. In both cases, scientists balance the multiple identities of their research resources. In front of a scientific audience, it makes perfect sense to state the moral difference between human and animal with statements like, 'We do things on animals that we cannot do on human beings.' In talking about a more general public in the interview situation, the animal turns into a sentient being and enters the category of precarious life together with starving children from another part of the world. Why is it the piglet in the situation of the conference is stressed as an animal less worthy than the human, and in the situation of the interview with the social scientists is stressed as morally equal to a human life?

I only slowly began to understand what was at stake in conference presentations and in the research director's appeal to life ethics when I was less strictly focused on *what* was being said, but more on the

distinctions made. In the conference presentations and in our interview with the research director, the moral question about worth and dignity operated as a kind of boundary work (Gieryn 1983) that set up boundaries between what can be known by the scientists who take part in the experimental work and what can be known by scientific and non-scientific publics. In the conference situation this happened by highlighting the animal as simply data (excluding its sentience). In the interview situation, this happened by highlighting its moral worth (including its sentience). That is, when moving the animal resource out of the laboratory, its moral worth was continually redrawn to facilitate its appearance as a legitimate resource upon its arrival in the spaces of translational medicine (conferences) and public communication (reports to the media).

To simply interpret these practices as a deliberate way of avoiding critique and resistance would miss what was at stake for the researchers in performing this boundary work. To understand the research director's urge to place his research in relation to life ethics, I will turn to Didier Fassin's analysis of the deployment of moral sentiments in contemporary governmental and non-governmental initiatives directed towards the most unfortunate, suffering and vulnerable individuals, such as helping AIDS orphans or disaster victims (Fassin 2012). Fassin argues that these initiatives, what he calls 'humanitarian government', are characterised by a paradox. On the one hand, humanitarian government is based on the universal recognition of other individuals as fellow human beings (a relation of assistance and solidarity) and on the other hand humanitarian government does not change the inequality that causes the disasters of war or illness (a relation of domination and inequality) (Fassin 2012, 3).

Although the research piglets are not humans and the practices in the laboratory far from the humanitarian interventions of assisting AIDS orphans, the research director himself compares research piglets to disaster victims ('I think it is a little similar to the photos of hungry children from the developing world'), and present in our conversation is both the articulated compassion towards the piglets (solidarity) and the silenced killing of them at the end of the experiment (domination). He mentions the moral sentiments towards precarious lives ('there are many feelings connected to the newborn and especially there are many feelings connected to suffering and illness'), and in the course of the conversation I myself provide him with the keyword 'dignity'. That is, humanitarian government designates positions in the conversation and unwittingly I come to represent these moral sentiments along with public concerns about responsible conduct and public engagement. In facing these sentiments

and concerns in the interview situation, we may see his boundary work as a way of caring for the 'bigger picture' (Law 2010, 64–6), that is, not losing track of the explicitly articulated promissory statements of infant health which the researchers strive to realise, yet do not know how and when will happen. He fears that the public may forget about this aim if the precarious piglet bodies are rendered visible. Moreover, in his statement about 'not becoming immune' we sense that establishing the boundary between what can be known by the public and what can be known by the researchers also serves to maintain his own sensitivity towards precarious lives so essential to running the experiments.

The double identity of the piglets as resources for human health and in themselves sentient beings came to the fore in a full-page article about NEOMUNE in the national Danish newspaper *Politiken*. Under the heading 'Incubator pigs are to support preterm infants' (Bach Madsen 2015), the article printed short interviews with several researchers from the NEOMUNE research platform and included a close-up photograph of a preterm piglet wrapped in a cloth in the hands of the researchers wearing laboratory gloves. In showing the newborn piglet, not the newly killed piglet at the end of the experiment, the article echoes the paradox of humanitarian reasoning described by Fassin: The photograph communicates the piglet as sentient life (morally like the human), yet the whole framework of the article pictures the piglet as a resource for human becoming (morally unlike the human) indirectly made known through the laboratory gloves, but not through showing its suffering and death. Taken together, the various ways of configuring the piglets in scientific presentations, in interviews with the social scientists and in reports to the media, illuminate how actors within translational research continuously strive to keep the right balance between knowing and unknowing to let the animal resource arrive safely in the Research and Development departments of industrial players and in clinics located in a global field.

## Managing resources in the NICU

I wish to end this chapter by providing a short excursion into life-and-death decision-making practices in the NICU in Copenhagen; the site inhabited by the infants whose health is seen as the ultimate goal of the life, suffering and death of the research piglets. My aim with this excursion is not to describe how feeding bovine colostrum to piglets has been translated into new dietary regimes in NICUs as this is still in the process

of being realised. Rather, my short description aims at exploring how also in this site unknowing is at work in managing resources and turning infants into viable lives.

The NICU in Copenhagen is the most advanced in Denmark and treats infants born as early as gestation week 23. In Denmark, healthcare services (i.e. treatment in the NICU) and social services (i.e. special education and rehabilitation of disabled children) are tax-financed and thus fully paid for by the Danish welfare state. The NICU has an explicitly family-based approach to the treatment of preterm infants. From the very moment a newborn child is rushed to the clinic, the parents will be offered a bed next to the incubator. They will be taught to take part in the daily care of their infant and be involved in all the difficult decisions about continuing or withdrawing treatment. In this setting, coming to belong in the Danish welfare state is closely related to becoming part of a family (see Navne and Svendsen 2019).

In the same way as it is important for the researchers in the pig laboratory to maintain the hope that the pain and death of the piglets in the here-and-now experimental practices contribute to creating life and health for infants in the future, it is also important for the clinicians in the NICU to be convinced that the treatments which the infants undergo and the suffering involved may in the end turn into a life worth living for these infants. To the clinicians, intubation and complicated and painful heart or gut operations are meaningful as long as there is a hope that these interventions in the end will result in a viable infant. By far the majority of the admitted infants are successfully treated and safely taken home by parents. However, when it happens that infants are so seriously ill that a graduation towards death within the near future can be predicted, the clinicians tend to see continued treatment as futile and argue in favour of withdrawing treatment.

In most of these cases, the parents share the clinicians' experience of futility and are ready to withdraw treatment, which means extubating the infant and letting him or her lie body-to-body with the parents until death occurs. Although rare, once in a while it happens that the parents insist on continued treatment and maintain the hope that a miracle might happen and that death is not the only possible future. In following such contested situations of decision making, my graduate student Laura E. Navne and I noticed how issues of limited resources found their way into discussions among clinicians. As the head of clinic expressed in an interview with us about one such specific situation, 'Overall, resources are not unlimited. Shall we continue with a very care-intensive treatment, which is futile and painful for the patient?' He and his staff did not think so

as such an infant would take up a space in the NICU from other infants who with care and technology may become viable babies. Also, a futile infant would exhaust his staff who were already working at full stretch doing their utmost to make infants viable, and for whom the experience of creating worthy lives was essential for them to maintain faith in their work so as not to resign from their job. Hence, the doctors did not blindly aim for continued treatment and prolonged life. Rather, they engaged in a difficult task when they balanced the expected life's worth of the infant with the situation of the family and the resources of the clinic and the welfare society (see Navne and Svendsen 2018 for a detailed analysis of such a case). Thereby the clinicians were not only treating the infant as an end in itself to be saved no matter the costs, but also saw the infant as part of a family and a welfare state and hence, we might say, as a resource for these collectivities. Consequently, the rare cases where clinicians and parents did not reach agreement on withdrawing treatment from infants who could not recover spelled out the central role in the clinic of *managing resources* (ensuring that some infants did not take up resources from other infants with greater needs; keeping staff by ensuring work conditions in which they were able to see their work as meaningful) and thereby *facilitating the future human resources for society* (investing work efforts and technology in infants who may become lives worth living).

At the same time as economics and prioritisations of resources are inevitable in the daily life of treating infants – every treatment is priced, the clinic has a budget to comply with, there are prices on items in the medicine room of the clinic, only the most premature infants are allowed to be fed the costly human donor milk – the clinicians did not consider it right to bring up the issue of resource management when talking to the parents. Also when parents were not willing to withdraw treatment in spite of the clinicians' advice to do so, the clinicians did not introduce to the parents the question of resources so pivotal in this situation. As the head of the clinic said to Laura E. Navne and me, 'I think that it is unethical [to mention money to the parents] … they are in the deepest imaginable crisis in their lives … money is of no relevance in comparison to life and death. How can the two of them [money and life/death] come together?' While these two cannot be separated in the daily management of the clinic and prioritisations between lives as the contested case spells out, the clinicians put efforts into separating money and life when talking to the parents as part of caring for them in their grief. Thereby the inescapable question of which lives to treat with societal resources and which lives not to treat constituted a specific geography – a 'careography' (Navne and Svendsen 2018) we might say – that separated the spaces in

which resource questions could be known and discussed (daily rounds, interviews with anthropologists) from the spaces in which resource questions were actively unknown (conversations with parents). This separation echoes the common view that the value of the human body should be kept separate from monetary transactions (Felt et al. 2009; Hoeyer 2005; Svendsen 2007) and illuminates a shift in 'money talk' between the laboratory and the NICU. In the laboratory, the researchers' articulations of a connection between economic value and pig life ('it costs another pig at the other end') constitutes the pig as a valuable resource; in the NICU, the clinicians' absence of such articulations of the calculability of life in front of the parents underlines the human infant as non-calculable, that is, as holding intrinsic worth. Hence, by unknowing and not exposing the inescapable prioritisations present in daily clinical practice, the clinicians separated money from human life and in so doing cared for the parents and maintained a high degree of understanding and empathy in their interactions with them, thereby upholding trusting relationships between healthcare institutions and citizens. Like the researchers when presenting their studies, the clinicians cared for the 'bigger picture' (see Law 2010; Navne and Svendsen 2018). They strived for the right balance between resource prioritisations and ways of helping parents through the grieving process and back to an everyday life outside the NICU.

## Knowing and unknowing in translational medicine

My movement across central sites in the infrastructure of translational medicine illustrates how aspects of the work of imagining, claiming, making and administering resources in the field of neonatology are open to experience yet actively unknown or silenced in specific contexts. In facilitating translation between bench and bedside, the possible *existential equality* between piglet and human researcher is unknown; in decision making in the NICU what is unknown concerns the inevitable selection of the worthy and the less worthy lives, what we may think of as the inescapable *existential inequality* between infants.

My study of this foregrounding and backgrounding of what is acknowledged points to the ways in which administering the boundary and moral tension between knowing and unknowing is part and parcel of making and managing resources for human health. Reflected in these activities is a notion of the 'proper human society' (see Ferry and Limbert 2008b) as one that frames the animal as a valuable tool for human health, sees the infant as an icon of life and potentiality, and

upholds the imaginary of infinite resources to treat every newborn life within the Danish welfare collectivity. In other words, the practices of claiming, making and managing resources are suffused with a notion of a 'we', which is closely linked to the welfare state society that regulates and subsidises pig farming, finances the NEOMUNE research platform, and finances and runs the public healthcare system. The researchers' and clinicians' sophisticated boundary work demonstrates a deep commitment to this 'we' in their striving for good science, in their commitment to collaborate in ways outlined by national research policies, in their engagement in securing a fair use of public funds, and in their care for infants and parents in the clinic.

While it may be that human exceptionalism and the boundaries between the species have been increasingly contested in both natural science (for example, De Waal 2001; Kohler et al. 2002; Oswath and Martin-Ordas 2014) and in social science (for example, Despret 2008; Haraway 2008; Buller 2014), my ethnography of the daily practices in translational medicine muddles this picture. These practices demonstrate that within a scientific framework in which the pig has moved closer to the human, asymmetries and disconnections between species and spaces are essential when bringing the pig into the clinic and managing resources in the clinic. At the same time as daily biosocial dynamics of animal-based translational science momentarily dissolve a clear distinction between the killable biological life of the animal and the liveable biographical life of the human, articulating and upholding this distinction is crucial to practices of translation. The pig and the human, sentient life and generalised knowledge, money and life worthiness, local dairy farms and global nutrition products are deeply entangled, yet actively separated or silenced in reaching the promise of human health, capital and science in translational medicine and in managing human health in the NICU.

## Coda

In jokingly describing themselves as 'our pigs', the researchers hinted at the ways in which they were both colleagues (of equal standing) of Mie S. Dam and me and our resources (of unequal standing) in the multi-species collaborative we all participated in. If it is so that the notion of resource presupposes 'a particular relation between humans as exploiters of resources and "nature" as the ground from which resources are exploited' (Ferry 2008, 52), this insight raises questions to the anthropologist about the right relationship between the anthropological

endeavour of producing knowledge about the boundary between knowing and unknowing (making resources in the form of ethnography) and the lives of the people who take care of this boundary on a daily basis (the ground from which data and analyses are made).

While including a social science study in a basic science/biomedical research platform surely holds the potential for engaging more ethical discussion without disengaging from the advancement of biological knowledge, this collaborative endeavour also cracks open conceptions of resource-making easily taken for granted in different epistemic practices. Hence, the question 'What is ethics here?' raised by the postdoctoral researcher applies equally to the anthropologist continuously trying to figure out the ethically right relationship between her informants and the anthropological knowledge production to which these informants contributed. In the same way as entanglements and separations are pivotal in making piglets into resources and managing resources in the clinic, entanglement and separations penetrate the anthropological scholarship. I know the worlds of experimental animal science and clinical neonatology from the inside through *engaged* solidary relationships with the professionals who with meticulous care and commitment handle piglets and infants. And I examine these fields by *separating* myself from their logics, thereby making it possible to question the common sense of the human–animal divide and explore the worlds that this common-sense divide produces. This is not without tensions. In literally moving between animal and human, laboratory and clinic, my ethnography is grounded in the daily interactions of people who think, feel, act, doubt, negotiate, at the same as it seeks to explore these worlds by examining the logics that not only belong to them, but encompass all of us. From this puzzled position we may begin to understand how human and animal lives are conditions of possibility for one another and how the strong notion of human potential and human uniqueness is woven into the practices of appropriating the pigs as resources for human health.

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## Notes

1. Similar descriptions of the laboratory practice can be found in Svendsen and Koch 2013 and Svendsen 2016.

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# Chapter 4
# Anthropology's End to Biodeterminism: A New Sociobiology

A. David Napier

Do new concepts in epigenetics and their implications for organic symbiosis demonstrate that sociobiology as it is commonly defined is actually a form of biosociology? After all, the sociobiology we have come to know is largely a product of the genetic fundamentalism promoted by E.O. Wilson and others in the 1970s – a fundamentalism now at odds both with contemporary epigenetics and with social neuroscience. Today these new fields open a number of routes for exploring how social life can influence biology in profound ways, merging more directly with new anthropological studies of science and technology (see also Lock, this volume). In this sense sociobiology's causal assumptions now seem not only premature, but also at odds with earlier and more ecologically-focused work in theoretical biology itself (for example, Ludwig Fleck and Georges Canguilhem).

## Sociobiology reconsidered

Redefining sociobiology in this volume as the impact of social practices on biological mechanisms, then, not only reorientates how we define 'biosocial' as the relationship between what we do and what we inherit (Napier 2013), it also helps us clarify the syndemic and symbiotic nature of human practices and their transformation over time (Singer 2009). In so doing, epigenetics realigns social anthropology with emerging trends in science, raising new and exciting opportunities for a 'new sociobiology'.

In this chapter, therefore, I develop an argument for rethinking sociobiology by demonstrating the utility of epigenetics in both theory and practice. This I do in the final section by examining the profound and

largely understudied effects of social practices on type-2 diabetes. I claim that not only is the illness primarily a consequence of social forces, but that our failure to attend to it successfully is in large measure the result of our previous prejudicing regarding biological causes as illness determinants.

## Darwin and stable change

In an era when scientific knowledge itself becomes a fetish (or *factish* as Latour [2010] would have it), many have seen in science a candid image of inescapable societal values. However, that awareness, too, is anything if not old: Marx, for instance, blamed Darwin for seeing the concept of nature itself as a reflection of English society: Marx's analogy is less a critique of Darwin's science than an expression of how deeply any concept of nature is itself a form of cultural allegory – a belief that nature, as it were, embodies culture.

Here, the science of developmental biology emerges as a deep commitment to core British cultural principles of Darwin's day. Dangerous biological transformation and upward advancement are, the English fortunately discover, ruled by a safer gradualism – allowing a great and stable chain of being to prevail within a prevailing and stable system of social class (Napier 2003). Scientific agnosticism replaces the Church of England as convictions about hierarchy and gradualism become reified within social Darwinism and eventually through a new eugenics. After initial protests, evolution emerges as a wonderfully safe religious allegory.

Indeed, religion was actually much more a part of evolution than many would like to think. In spite of the common juxtaposition of evolution and the Church (to this day), Darwin was heavily motivated by religion. It is well known, for example, that Darwin's hesitance in publishing his work on evolution was the result of his respect for his wife's Christian beliefs and his desire not to upset outstanding social hierarchies. Darwin was as much a participant in the hierarchies of the society he inhabited as he was a disbeliever in their merits. It was T.H. Huxley, after all, who saw in Darwinism an opportunity for meritorious scientists to challenge the class system by arguing for intellectual status – for an upward mobility based on a hard-working mind. Though evolution challenged biblical dogma, it also, in other words, comforted those who did well in life by allowing them to think themselves fit. While Darwin was vexed by Spencer's notion that charity got in the way of nature, it emerges from Darwin's correspondence with Spencer that he, if uncomfortably, shared some of Spencer's views (correspondence of Charles Darwin, 1985).

Since intelligence was also subjected to fitness, class and progress after Darwin emerged as no longer circumscribed by religion. They now also could be demonstrated scientifically. Eventually, 'fitness' would allow a world of intellectuals to appropriate a system of class, to maintain its hierarchies, and to embed those hierarchies yet more deeply in a hyper-individuated society of autonomous, achieving selves. Social Darwinism, in other words, evolves as a natural outcome of evolution, with genetic privilege (now, inherited intelligence rather than social class) being proof of deservedness. Hence began the long road of eugenics and, today, genetic selection for intelligence, the bell curve, and so on.

In this view, science succeeded in replacing religion not because science and religion actually differ, but because they both applaud a similar cultural ontology. For inherited status, gradualism, and hierarchy all transcend the distinction between religion and science, confirming that each of us has a stable place in a stable world of more and less fit selves and others. Status – that is to say, 'fitness to rule' in politics, academics and the arts – would remain resilient against rapid change, and also resilient against the principal fear of the inherited classes of the era: this being the equation of status with power and the consequent upward mobility of the newly emerging social climbers – the so-called 'bounders' of the Industrial Revolution that populated Dickens' novels – the tainted and infected enemy within the landed gentry.

Readily, there is a blue-blooded message in the survival of the fittest that is every bit as powerful as the concepts of God, country and inherited social estate. The major difference for Darwin's era was that those privileged by class would now be obliged to compete with successful industrialists and intellectuals who also wanted to prove themselves more 'fit' (to rule).

Darwin's science of nature, in other words, may have emerged as the result of carefully observed science, but it also emerged as a comforting reflection on established cultural values that reinforce the ontological placement of selves versus others in a prior, persistent and enduring world of winners and losers. The world is not static; but change remains a comfortably slow process. One can see such a master myth quite blatantly, for instance, in immunology – where a solipsistic Cartesian 'self' becomes not only the basic premise of biomedicine, but more generally, a kind of subliminal ontology that underscores its power as a valued cultural category. Selves survive by eliminating outsiders. Indeed, 'recognition and elimination of non-self' is the key premise of immunology to the degree that even when immunology rethinks the contingent nature of survival, it still does so on the grounds that any new theory involving the amelioration of self and other emerges out of an outstanding dichotomy between a self and its external environment.

Mark Johnson has said much on the social power of such shared forms of subliminal meaning (Johnson 1987); but the important point here is to mark the ethical and religious force of evolution and its nod towards determinism and hierarchy. For these very Enlightenment categories of achievement have also been adopted without examination by religion and science alike – not only as that devotion to personal achievement which is the prerequisite for academic success, but in its survival focus on a prior, persistent, and autonomous self. Indeed, even modern efforts to decentralise the ego, from Latour to Deleuze, only make sense if we accept the resilience of an egocentric Enlightenment platform in the first place. The merging of a self and its environment, in other words, cannot be conceptualised without first acknowledging the two categories as distinct. Theory (in that a theory is either *mine* or *yours*) is itself an Enlightenment ontology.

To put it simply, any trope by which a self merges with its environment carries with it the presumption of a previously autonomous, prior and persistent 'self'. For this reason, Western philosophy will never escape its Cartesian foundations, which is why the philosophy of science can add little in the way of reshaping epigenetic paradigms. Such reshaping, if it can occur at all, will more likely emerge from anthropology (with its focus on non-Cartesian categories of self) than from philosophy (wherein innovation builds on outstanding categories of thought).

In conclusion, philosophy of science – in which Cartesian-like Martians represent exotic ontologies – stands as a poor substitute for the countless non-Cartesian ontologies evidenced in the diverse cultural traditions that anthropologists have done their best to understand. Were we not so wedded to the survival of the self at all cost, one might easily envision other forms of relations that bring all of us closer to the environments we inhabit.

Nonetheless, we cling to the idea that genes can be selfish (Dawkins 1976) even though (like viruses) they have no mobility or indeed any capacity for action. Genes, in fact, are just information – that is, they possess no capacity for action or self-interest, which is to say that our ascribing behaviours to them constitutes a form of animism no different than the religiosity that Dawkins himself so boldly critiques (Cossu et al. 2017; Napier 2012, 2013). What epigenetics shows us, in other words, is just how fundamentally wrong both the social Darwinists and the biodeterminists are about our autonomy.

## Selfish genes?

There is a common word in Latin that long ago found its way to the centre of genetic debate. The word is *saltus*. It is a noun meaning 'jump', or 'leap'.

It was the one thing, according to Charles Darwin, that nature just does not do. For Darwin, evolution works because it happens over a very long period of time. *Natura non facit saltum*: 'Nature does not make a leap' (Darwin 1859, 194). If change happened too quickly, random mutations would, as so many science fiction novels and movies claim, transform destiny overnight. Humans could not evolve from other primate forms if changes happened suddenly. Random mutations would prevail, and change would occur in a wholly unsystematic manner (Napier 1996).

Probably more than any other, this key idea is what led to social Darwinism, Herbert Spencer's own take on evolution, which (their correspondence shows [Darwin Correspondence project]) Darwin by and large agreed with. In Spencer's view, nature should be left to carry out its destiny and over time to eliminate its weaker forms (Spencer 1864). We only interfere to produce advantage for those who already rule. Let nature, that is, eliminate the weak, the aberrant, and the deformed; and let humans assist nature by making decisions that allow the fittest to do better in what they have been selected to do. Hitler may not have adopted a coherent or scholarly view of Darwin (Richards 2013), but he loved the idea of natural selection and its social implications (Sherratt 2014). So did a number of respectable thinkers we wish more to defend, even if Darwin came to find some of what Spencer wrote unacceptable if not outrageous.

But in the 1960s, after a decade of work, a set of experiments focusing on the domestication of animals began to show the profound symbiotic impact of social environments on inheritance (Trut 1999). In the 1950s, Dmitry Belyaev, a Russian geneticist, decided to see if tamer foxes could be bred for the fur industry. Selecting animals that were less aggressive (an undesirable trait in caged animals competing for food), Belyaev began both the selective breeding of foxes that showed tolerance for humans, and socialising those selected cubs to the presence of humans. Not only did he soon produce domesticated foxes, but something else quite unexpected happened: the foxes began to bark, their ears dropped, and the colour of their fur changed. They became playful and unafraid of humans. They even responded to being called by their names. Within a decade, highly domesticated behaviours appeared, but so did a different sort of animal.

What was notable in Belyaev's work were two things: first, his discovery that a cascade of other genetic changes was expressed simply by selecting for tameness; and, second, that *controlled social conditions* – the laboratory in which the social encounters of foxes, and their breeding habits, were determined by particular rules – very quickly influenced these genetic changes. As adrenal functions (the fight-or-flight syndrome)

changed, so did skin colour; so did dopamine and noradrenaline, which influences response behaviour. In short, the social activity of selective breeding led to a cascade of remarkable and surprising biological changes.

Nearly everyone who has shown an interest in these experiments focuses on the strong impact of inheritance on domestication – on dogs in particular, and how quickly domestication can occur. Control dogs by selecting for compatibility with humans, and what you get is a rapid change in gene expression, even creating a new kind of organism. Indeed, some form of this socialising experiment must have happened long ago that led to our having the remarkable variety of domesticated dogs we now enjoy. What Belyaev demonstrated was not only the importance of phylogeny but a strong example of the deep significance of what we now call epigenetics.

However interesting this experiment may be for explaining why domestic dogs exist (and why they so little resemble their wild cousins), what is perhaps more telling (though largely neglected) is what can be learned about the effects of controlled environments on the behaviours of the fox, and on what actually gets expressed genetically. Giving rather more trusting foxes a chance to reproduce – foxes that did not fight or flee when approached – led to a wide range of genetic expressions that were latent.

Looked at in this way, we realise that social exposure (engagement with 'the other') is really the key variable that allows many genes to function, or to shut off. Leave the fox to one set of interactions in the wild (an environment 'controlled' by nature) and what happens is that certain traits are expressed; put the fox in another controlled setting (one controlled by humans) and you rapidly alter the fox's capacity to change and the ways that it changes. It is here our lesson resides; for Belyaev's experiments show not only the influence of gene selection, but also the dramatic effects of controlled social environments, of engaging complexly in specific social ways, on that process.

In other words, human selection for tameness is not 'natural selection'; it is 'human selection' – a social process about creating social environments in which certain genetic traits emerge. As such, it has quite a bit to do with evolution, but as much, or more, with the effects of social environments – which experimental settings also undeniably are – on genetics.

Might the same be true for other complex genetic changes, like the proliferation of mysterious allergies, or adult-onset diabetes? We will explore this possibility at the end of this chapter.

However, now fast-forward to 2006 and the awarding of the Nobel Prize to Andy Fire and Craig Mello for their 1998 work on genetic interference, on so-called *gene silencing*. Genetic interference takes place when RNA molecules cause a biochemical interference with cells responsible

for transmitting genetic codes. In effect, what this interference causes is the degradation and eventual disappearance of those molecules. In other words, what we are witnessing is the expression of viral information that makes the 'selfishness' of evolution a questionable idea to say the least. Here, a bit of information (which one's own supposedly 'selfish' cells bring life to) completely alters a line of inherited information otherwise considered wholly genetic.

But Fire and Mello did not discover this idea; their experiments only showed its reality. The 'discovery' of Fire and Mello was to understand how this disappearance (the gene 'silencing') could become permanent. Because the necessary proteins are no longer manufactured, the genetic information they otherwise transmit can no longer be expressed. In short, genes may be permanently silenced by the presence of random viruses from the environment – viruses carried through social encounters. Life (perhaps to Watson and Crick's lament) is not just a function of the determining powers of DNA. It is a function of how an organism relates, or fails to relate, to its social environment. In fact, the DNA story will become increasingly less stunning as we learn more about how the 'phylogenetic' encounters of socially engaged organisms reshape our destiny.

As biologist Michael Skinner and his colleagues have recently shown in their work at Washington State University, epigenetic factors in mice can now be traced as far as the fifth generation and even beyond (Skinner 2014, 49). Yet, despite the mounting evidence, many biologists still recoil from the idea that environmentally induced epimutations can settle into the germ line. 'The hypothesis seems to contradict a long-established belief that nearly all epigenetic marks are erased from the DNA and then rewritten during the reproductive process – not just once but twice. These processes, the reasoning goes, should wipe clean any acquired epimutations before they can cause trouble in the next generation' (Skinner 2014, 51).

While some may object, arguing that the effects of genetic interference are not profound, in fact many viruses possess the necessary double-stranded RNA capable of triggering the permanent silencing of genes if they have the environmental opportunity to do that. What this means is that organisms are not wholly fated by their 'selfish' genetic makeup. In fact, many can be profoundly transformed by extending themselves, like the foxes in Belyaev's experiments, beyond their otherwise defined boundaries and engaging in new and novel forms of sociality – whether those new environments are chosen or forced upon them, and whether those forms of exposure enhance the expression of genes or shut those genes down entirely (Napier 2013, 33). What this work tells

us, in other words, is that sociobiology – the impact of the environment on the biological – is just as important, perhaps more important in terms of big changes, than biosociology, the impact of biology on our social makeup.

The genetic notion of biodeterminism, then, is not only based upon Enlightenment notions concerning prior, persistent, and self-interested selves, but also upon a deep skewing of the effects of biology over social environment on future biological makeup. What the science of epigenetics makes clear is that biodeterminism is not only a kind of teleology, but an ontology rapidly being undermined by science itself (Napier 2012). New knowledge within biology, in other words, exposes modern-day Darwinism as a kind of religious dogma – an acceptance of fate without acknowledging the profound consequences of human intervention on our collective destiny.

By contrast, biology increasingly suggests how engaging with the 'other' profoundly alters what we once assumed to be immutable; for evolution is not a theory in the sense of having predictive value; it is a form of explanation – a making sense of the past, a teleology, if you will – that offers us explanations in the form of stories about why things happened as they did. It has, we are forced to accept, only limited (if any) predictive value. Radical genetic expression – true transformation – occurs, as our foxes and genetic silencers show, when novel social events facilitate the release of certain forms of biological expression.

Looked at this way, the events that change the course of human history all make the biggest impact when they are at odds with our empirical practices and the inductive assumptions that rule our expectations and our sense of the normal. One might even argue, as does Nassim Taleb (2007), that the relevance of such events is inversely proportionate to human understanding – that is, to knowledge. And the problem is, if anything, made worse by those who think they can predict the unexpected, leading us to believe we can control what we do not yet see. Nature is nothing if not unpredictable and risky.

Take the fight-or-flight syndrome, a phenomenon I studied some 30 years ago (Napier 1986) and is still central to the problem of prediction. We do not know if the frightened lion will run or attack; and, indeed, its facial 'expression of arrest' is the only one it makes that is wholly unreadable outside of its social context (Figure 4.1). While evolution may argue that its aggressive attack or the strong legs on which it flees are what make it 'fittest', we cannot in any way determine in advance what the lion will do, or if its doing so was selective. We do not know, that is, if it attacks or flees, or if in fleeing it survives or falls prey to another lion waiting in

**Figure 4.1** 'Expression of Arrest'. Source: GollgGForce. CC BY 2.0.

ambush. Unless we begin to think epigenetically about the social context of the confrontation itself, we have only the presumed cause to proclaim in retrospect once the outcome is evidenced. Nature, in other words, is much more complex and merciless (and indeed beautiful) than any laboratory experimenter could ever show!

While E.O. Wilson's *Sociobiology* (1975) may, therefore, supply a mythic 'master narrative' of biologically determined development, today that reality seems much less determined. Harsher though reality may be, evolution's lack of predictive value means that social events have significant consequences that are not only unknown, but also unknowable in advance.

## Bio-prejudice and biodeterminism: The diabetes example

While anthropology has called for work that describes, assesses, and even measures synergies amongst complex illness drivers, both the evidence based on complexity as well as measurable evidence regarding the effects of social practices and lived experience on biology remain underdeveloped if not non-existent.

Merrill Singer's attempt to re-conceptualise diseases in their biosocial contexts (*syndemics*) is a call to gain a better understanding of the complex social factors that influence mortality and morbidity. But the metrics for assessing how socially integrated individual responses affect health outcomes has yet to be established, even as Singer finds mathematical modelling relevant and promising (Singer 2009). Type-2

diabetes provides a dramatic case in point: our prejudices about the biological determinants of health have clearly not only led to disastrous consequences at the level of human misery, but have also cost us dearly in financial terms.

Though diabetes epigenetics is flourishing as a growing field of research, pulling apart social and cultural drivers in an individual's life from genetic changes that are inheritable is difficult. We know, for example, that rates are increased notably where antibiotic use is common (Mikkelsen et al. 2016), but without long-term longitudinal studies it is difficult to establish which effects are permanent in the germline and which are modifiable over generations. What is more, the alarming rise of the illness leaves little time for multi-generational research.

With the world's population ageing, the growth of global food networks coupled with the consumption of high-energy low-nutritional foods, and a rise in sedentary lifestyles resulting from urbanisation and related constraints on exercise, much of the world finds itself unprepared for the scale of the diabetes threat. Diabetes may well bankrupt healthcare systems globally, as even in countries with comprehensive health care, non-adherence to treatment still runs high while diabetes co-morbidities proliferate. In the UK, for instance, only about 65 per cent of the diabetic population are able to adhere to treatment regimens, costing the country £10 billion annually for diabetes-related co-morbidities out of a direct healthcare expense of some £66 billion (Diabetes UK 2014) – that is, more than 1/6 of all health expenses lost to non-adherence in one hugely devastating illness, in a country where early detection and prevention (when the disease is reversible) are feasible.

That's a 'good' picture from a nation thought to embrace the idea of integrated community care. The realities are much less edifying in places where no such care exists. Elsewhere, the situation gets much worse. On the opposite side we see developing economies struggling deeply with the diabetes epidemic. It is estimated, for instance, that by 2035 diabetes will consume the entire health budget of Mexico. At the same time, wholly biomedical responses to diabetes produce desired outcomes for only 5 to 7 per cent of people suffering from the illness. As we will see below, the problem of diabetes is largely socially mediated, not only in 93 to 95 per cent of sufferers in Mexico, but throughout the world. The cumulative consequences of this chronic illness in human and economic terms are world-changing.

Part of the problem is complexity itself – both at the level of lived experience, and at the level of research design. But at least complexity has finally been recognised by a number of governments and embraced,

for instance, by the European Commission in its 'health in all policies' approach (Ståhl et al. 2006). However, announcing the need for cross-sectoral action on illness (by asking all sectors to consider the health implications of policy decisions), still puts us a long way from understanding what actions will be required to reverse the progress of the illness, knowing which strategies are feasible, and determining how we prioritise limited resources to address this 'silent' epidemic.

Figure 4.2 provides one list of policy domains that allows us to understand what may be required if we are to rethink health promotion more generally. Indeed, taking the domains considered to constitute 'all policies' (shown in red below), and thinking about just one or two of the diabetes-related areas needing attention (parenthetical comments in black), allows us easily to see just how complex the problem of reversing the proliferation of diabetes actually is.

In that as little as 1 to 5 per cent of diabetes treatment in poorer countries is successfully accomplished through biomedical care alone (and in the wealthiest of countries the figure is still less than 40 per cent), the need to understand what makes individuals socially, psychologically and environmentally vulnerable to diabetes is not only urgent, but critical to the stability of healthcare systems worldwide.

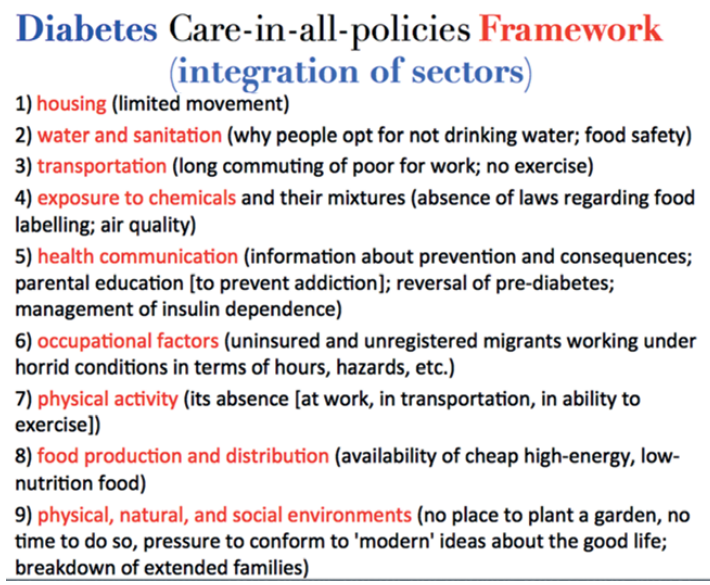


**Figure 4.2** Examples of challenges to diabetes care across policy domains. Provided by the author.

A graphic alarm regarding the damaging consequences of biodetermined prejudices in the treatment of diabetes may be evidenced in what is called the 'rule of halves'. Though this 'rule' was developed in order to get a better understanding regarding treatment failures in primary care (Hart 1992), it has now been adopted for describing the epigenetic, social and cultural determinants of health in non-communicable diseases, and in type-2 diabetes in particular.

According to this rule, of all of those suffering from diabetes globally, only about half have been diagnosed. Of those diagnosed, only about half are receiving appropriate medical care. Of those receiving appropriate medical care, only about half achieve their treatment targets. And of those achieving their treatment targets, only about half achieve their desired outcomes and live their lives free of diabetes-related, co-morbid complications.

This 'rule', of course, varies widely from one social setting to the next – from city to city, and also from country to country. In the UK, for instance, 36.8 per cent of diabetics achieve their treatment outcomes. While in some economically struggling countries this figure can stand as low as 3 to 4 per cent, the relevance of social factors to biological outcomes could not be more telling; for even in a country having a comprehensive national health service, still some 63 per cent of those living with diabetes fail to achieve treatment targets as the result of complex social, psychological, cultural and economic factors that influence the way people live their lives from day to day, and how their genetic makeup is reshaped by social factors. In countries lacking universal health coverage, this figure rises sharply from 63 per cent to as high as 97 per cent.

However, while complexity itself is discouraged in science – where randomised control trials (RCTs) eliminate, rather than compound variables, and where high-impact scores for publication favour RCTs over field-orientated, social research – a review of adherence itself shows more dramatically why our evidence base for diabetes has been stalled by the way we favour biodeterminism as a mode of thought.

Indeed, the true impacts of our biodeterminist prejudices are only seen when we review the 'rule of halves' not as an expression of how many sufferers fail to achieve treatment targets, but as an indictment of biodeterminism itself. For we can easily re-interpret this 'rule' to show just how much of what we consider biodetermined is socially determined and/or epigenetic.

The first proof is the fact that addiction to sugar is a largely social and cultural problem. An infant's brain is far from fully developed. While the brain/body ratio of human infants and those of chimps are the same at

birth, that ratio rises two- and then three-fold in humans in the child's first years of life. By the time we are adults, our brain-body ratio is 3.5 times that of a chimpanzee. The fact that the human brain is so under-developed at birth means that addictions (such as to sugar) can easily be created by social behaviours, setting aside the possible shutting off of genes by the previous generation's own social behaviours. In other words, our social habits in infancy (food intake, decision about antibiotic use, etc.) are being made in an infant's life at a time when its brain is developing quickly and the infant is yet to develop its acquired immunity. At the same time, acquired immunity in an infant takes a full 18 months to develop. Merging research on brain growth, sugar addiction, and acquired immunity, we can readily see how the first year and a half or so of social life not only will influence the life-long foundation of cellular health, but also how our social actions impact biology in foundational ways.

Second is the effect of poverty and what is now called the 'nutrition transition'. Cultures emerging from malnutrition are especially vulnerable to high-energy, low-nutrition foods. They not only cost less than healthy foods, but seeing someone overweight or even obese can be viewed as a state of good health when emerging from a life characterised by extreme food shortages. Indeed, there is a growing anthropological literature on preferred large body sizes (Figure 4.3) that needs to be understood now if diabetes is to be reversed (for example, Popenoe 2004; Harris 2016; Yates-Doerr 2016). Mexico, for instance, now leads the world in childhood obesity, even surpassing the US; and Mexicans, likewise, repeatedly choose unhealthy body shapes as ideal, well over the median of five and sometimes higher than six.

Third, and perhaps most telling, is the degree to which non-biodeterminist models of diabetes have been neglected in care and treatment. While the 'health in all policies' approach cited above has had considerable impact on the re-conceptualising of illness, it has virtually no effect on our willingness to prioritise the social and cultural determinants of health and wellbeing. Social science studies of diabetes remain underrepresented and underfunded in spite of recommendations to the contrary. Even the very funders who promote such integration across sectors timidly revert to funding life science research when coffers diminish. The effects of the culture of biomedicine prevail, then, not only amongst bench scientists, but amongst funders (such as the European Commission) that profess publicly to have changed priorities.

Such facts can be clearly evidenced when we reframe the 'rule of halves', not as a 'treatment problem' but as a reflection of successes and

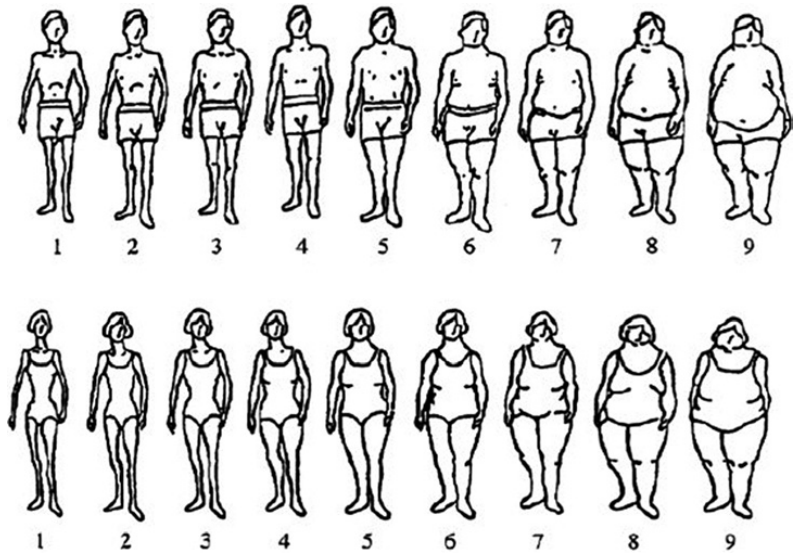


**Figure 4.3** Variability of preferred body size. Source: Chukwunonso, E. E. 2015. 'Body shape dissatisfaction is a "normative discontent" in a young-adult Nigerian population: A study of prevalence and effects on health-related quality of life', *Journal of Epidemiology and Global Health* 5 (4, Supplement 1): S19–26. https://doi.org/10.1016/j.jegh.2015.07.003.CC BY NC-ND 4.0.

failures of biodeterminism. For once we reshape this 'rule' as an indicator of how much of diabetes is or is not biodetermined, we see also the true folly of our prejudices. Indeed, given what is lost to the medicalisation of diabetes and the fact that some 2.1 billion people (30 per cent of the world's population) suffer from only one of its risk factors (obesity), it might be better and more fruitful to think less about the 'rule of halves' and what it indicates about non-adherence, than about those undiagnosed who have been ignored because the social origins of their illnesses have not been adequately addressed. Here, we might rather speak not of the 'rule of halves', but of the 'rule of have-nots' – that is, the extraordinary level of risk that biodeterminism itself has created by ignoring the profound effects of social life on biology.

To say, that is, that biodeterminism is responsible for the rapid and devastating effects of diabetes may be too strong a judgment. However, the conclusion, nonetheless, begs to be drawn.

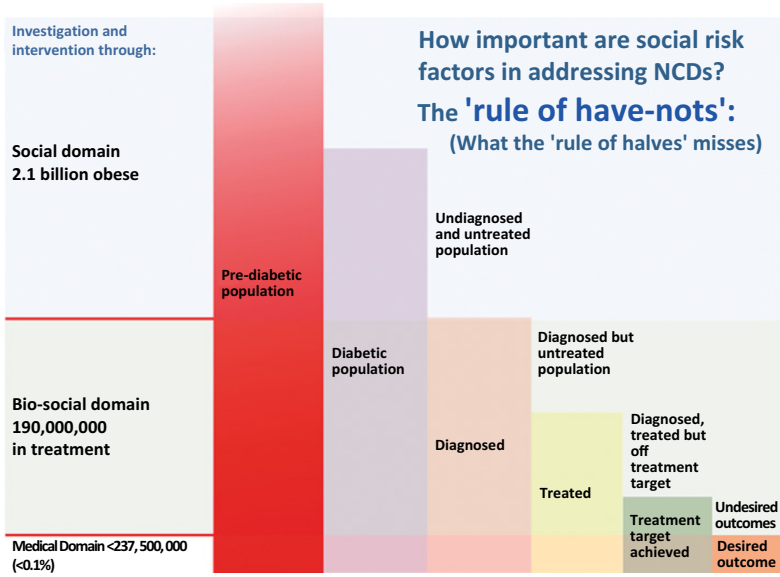


**Figure 4.4** The 'rule of have-nots'. Provided by the author.

## A new ontology

In *The Age of Immunology* (2003) and later in 'Nonself help' (2012) and 'A new sociobiology' (2013), I argued that Enlightenment categories of selfhood have made us largely incapable of understanding the merits of seeing how a self is symbiotically influenced by its environment, and variably defined ontologically. I also have argued repeatedly that science itself is increasingly accepting the limitations of its insistence on defining survival in terms of a self that is prior, persistent and self-interested.

Today we stand at the threshold of understanding how new evidence demonstrates not only the limited utility of biodeterminism, but the degree to which selves are realised through symbiotic relations within diverse environments that are affected not only by notions of the self, but of time and causation. Reverse transcription is one example; retroviruses another (Napier 2003); for in these cases the effects of life are, as it were, recursively rewritten, defying the permanent determinism of genetic processes, and showing us clearly how much more readily an organism can succeed in life by adjusting to, rather than eliminating, the perceived 'other' in its environment.

But biodeterminism as a monolithic ideology dies hard, as we hold onto the idea that the fittest survive principally by the recognition and

elimination of non-self – immunology's core trope. Indeed, even the late emergence of stem cell research and regenerative medicine in general can be traced specifically to modern science's unwillingness to accept that genes and viruses are just information: they lack the capacity to act unless life is brought to them by living cells. Viruses cannot invade us on their own; and that little fact forces us to realise that our immune systems are as much symbiotic adaptation systems – search engines, as I have called them – as they are defence mechanisms.

So why have we clung so desperately to our deterministic models that see science and its randomised control trials as the gold standard? We live and breathe, survive or die out, by the information viruses and genes contain. But that information is useless unless socially contextualised. We are invaded or directly affected by neither genes nor viruses, but we are profoundly affected by cells that bring their information to life. For viruses, viral proteins, and genetic data more generally are all just that – information that our cells bring life to. They have no motility, reproductive capacity, or agency in and of themselves. In fact, they can lie dormant for thousands of years awaiting one of us to assimilate their information and bring to life its effects on our cells.

Though the point may seem simple enough, it is nonetheless profound at the level of redressing the mistakes of biodeterminism. Once we accept how culturally biased has been our use of invasive and defensive metaphors, we also open the door behind which can be found countless other notions of pathogenicity – some more 'demonic' than the little armies of viruses we popularise in explaining to children why they should wash their hands; some indeed much more symbiotic. Either way, if we continue to think of our local environments in ways that only reiterate tired categories, our ability to revision the future will be seriously mediated by our own ignorance. And that goes for our views of healthcare too: if we continue to separate the social and the biological, and to define illness only in biological terms, we will surely fail in seeing life as anything other than medicalised.

While escaping our own cultural prejudices comes at a very high cost, there are remedies. As Mark Twain once famously said, 'travel is fatal to prejudice, bigotry, and narrow-mindedness' (Twain, 1869). Myopia has a very high cost; but engaging other modes of thought can not only be refreshing but enlightening. For now, we must wonder about the steep gradient we must climb to transcend our obsession with biodeterminism. Are there metaphors from other cultures, other ways of seeing, that perhaps can provide new and better models of how we not only define our

environments, but are defined by them? Let us hope that Twain's 'prejudice, bigotry, and narrow-mindedness' can be transcended by attending more authentically to those other voices.

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# Chapter 5
# Tribes without Rulers: Bacteria Life in the Human Holobiont[1]

Allan Young

> [B]acterial information processing is … incredibly sophisticated at coordinating processes involving millions of individual events and at making them precise and reliable … [B]acteria display astonishing versatility in managing the biosphere's geochemical and thermodynamic transformations: processes more complex than the largest human-engineered systems. This mastery over the biosphere indicates that we have a great deal to learn about chemistry, physics and evolution from our small, but very intelligent, prokaryotic relatives. (Shapiro 2007, 816–17)

My subject is a 'model organism' referred to in these pages as 'bacteria' or 'bacterial society'. This model is an amalgam of a thousand or more species of bacteria that live and die inside the human body. There are notable differences among these species, but they are irrelevant to my interest here: a contrast between real-life molecular autonomy and thoughtless biodeterminism.

A model organism is a well-studied species employed by researchers in order to get access to information about some other, less-understood species. The relation between the model and target species is generally homology: the two species have a shared origin and they preserve and therefore share certain features. In this special sense, we can think of model and target organisms as *parallels*. Biological researchers utilise many model organisms of course. Bacteria are considered especially useful for studying gene regulation.

In unusual instances, the *parallel* species also *intersect*, in the sense that the model organism has a place in the life of the target organism. Bacteria are unusual in that the distinction between parallel and intersecting relations is perversely blurred – 'perversely' in that the relationship

deviates from what was formerly understood to be normal. In 1973, Francois Jacob, Nobel laureate and spokesman for what was the normal view at the time, wrote that:

> It is perfectly possible to imagine a rather boring Universe without sex, without hormones and without nervous systems peopled only by individual cells reproducing *ad infinitum*. This Universe in fact exists. It the one formed by a culture of bacteria. (Jacob 1993, 263)

Evidence accumulated over the next decades contradicts Jacob's conclusion. Bacteria are revealed to be social animals, not homogeneous masses of individual cells. Although it is true that they lack a nervous system in the conventional sense, the bacteria resident in the bodies of vertebrate hosts produce and respond to neurotransmitters and regulators. Moreover, while bacteria are certainly mindless, it would be a mistake to conclude that they lack cognitive abilities, or that they are incapable of behaviour, such as spitefulness, that can be usefully compared with hormone-fuelled acts in higher animals.

## Part One: The cell state

In 2007, the science journal *Current Biology* published a selection of articles on the theme that all life is social. More specifically: 'Group living intensifies two opposing forces. On one side, proximity exacerbates conflict for local resources. On the other side, cooperation with neighbours may enhance group efficiency and aid in competition against other groups' (Frank 2007, R648). This idea signals the revival of interest in the social dimension of biological life – an idea that was popular during the nineteenth and early twentieth centuries among naturalists, evolutionary biologists and their publics. In 1902, Peter Kropotkin, erstwhile Russian prince, economist, geographer, evolutionary thinker and proponent of anarcho-communism, published *Mutual Aid: A factor of evolution*. In this book, Kropotkin argues that humans are inclined to cooperate with people close to us, compete, sometimes aggressively, with outsiders, but these tendencies will be modified by environmental factors and other contingencies. The innateness of these tendencies is vouchsafed by evidence of their evolutionary origins:

> As soon as we study animals – not in laboratories and museums only, but in the forest and the prairie, in the steppe and the

> mountains – we at once perceive that though there is an immense amount of warfare and extermination going on amidst various species, and especially amidst various classes of animals, there is, at the same time, as much, or perhaps even more, of mutual support, mutual aid, and mutual defence amidst animals belonging to the same species or, at least, to the same society. Sociability is as much a law of nature as mutual struggle. (Kropotkin 1902, 12)

Sociability is a characteristic of invertebrates as well as vertebrates, and is well established for ants, termites, and bees. 'Mutual aid is met with even amidst the lowest animals, and we must be prepared to learn some day, from the students of microscopical pond-life, facts of unconscious mutual support, even from the life of microorganisms' (Kropotkin 1902, 15).

The social life of microorganisms was a subject of interest among biologists during the second half of the nineteenth century. Debate focused on the so-called 'cell theory', according to which every organism, including humans, is comprised of smaller, self-reproducing organisms. Biologists are concerned with relations between the superorganism and the constituent organisms: they want to know *how* the constituents are connected (generally via evolution, anatomy, physiology) and *why* constituents are connected. When constituents are sentient entities, the 'why' answer will mention their drives, motives, or intentions. When constituents are not sentient, why answers will explain that constituent parts *enable* the superorganism to perform – this is *their function*. Moreover, when there are no satisfactory answers to how or why questions, we have a puzzle – the puzzle of 'the one and the many', 'the most central of all philosophic problem', according to William James (1907, 51).

It is a century and a half since the cell theory was introduced, and biologists are still seeking answers to the how and why questions. A popular thesis in the nineteenth century traced the evolutionary origins to primitive, free-living cells, known as 'protists'. In Ernst Haeckel's narrative of these events, protists preferring a sessile group life surrendered their independence, to create the first multicellular organisms. How and why questions were addressed via the metaphor of the 'cell state': an egalitarian 'cell republic', representing multicellular plants, and a hierarchical 'cell monarchy', representing multicellular animals, in which cells are subordinated to the central nervous system and the brain. Within the cell state, cooperation and coordination would prevail, and growth would proceed through cell division. Simple cell division would not explain embryonic development, however, and this difficulty remained unresolved.

Ultimately, beginning in the first decades of the twentieth century, the metaphor of the cell as an autonomous citizen within a larger social body lost its allure. At this time biochemical and physiological investigations began to replace morphological and evolutionary considerations of organisms and cells. As biochemistry matured as a professional discipline, another metaphor came to dominate, one more suited to the particular types of questions being pursued by the new breed of investigators, so that today one more commonly hears the cell described as a 'chemical factory' (Reynolds 2007, 74).

## Part Two: Bacterial society

This is where we left Kropotkin, the year is 1907 and he is thinking about pond life. A newly discovered free-living microorganism, the bacterium, is attracting attention. Koch and Pasteur have established the medical and industrial importance of bacteria, and significant technological developments have followed. However, misunderstandings about bacteria persist. Some biologists believe that they are not true cells, since cells must have nuclei. If bacteria are cells, it is uncertain whether they belong among plants or animals. In either case, the bacterium is a primitive form of life: 'a simple automaton, blindly following its genetic programming … [with no] personal idiosyncrasies, let alone a social life' (Gardner and Kümmerli 2008, R1021). Kropotkin wisely excluded this 'generic loner' from his book on mutualism.

Today, experts know otherwise. Bacteria are biologically complex organisms, operating in unexpected ways. For instance, the bacterial cytoskeleton regulates and executes key cellular processes in a manner analogous to the operations of organelles in the nucleated (eukaryotic) cells that compose body tissues and organs. In addition, bacteria lead complicated social lives, interacting with different species – bacterial and otherwise – within multicellular communities. When describing bacterial social life, I will rely on the language employed by contemporary microbiologists.

Microbiologists write that, within these communities, bacteria 'can glean information from the environment and from other organisms and interpret the information in an existential "meaningful" way, i.e. by building an appropriate colony structure … and [may even] learn from past experience' (Ben-Jacob and Levine 2006, 198). Their chemical communication is said to be like linguistic communication, in giving contextual meaning to bits of information connected like words into sentences, and exchanged between individuals via a dialogical process through which these bacteria

assess local cell density: a procedure known to researchers as 'quorum-sensing'. This arrangement tells bacteria when they are numerous enough to overwhelm the immune system defences of the host organism. Until this threshold is reached, bacteria modulate the expression of their virulence genes, thus forestalling the timely mobilisation of antibiotic defences by suppressing evidence that advertises their presence to 'target cells'.

Some quorum-sensing systems are operated by a single species (or genus), and their messages are unintelligible to outsiders. In multi-species systems, outsiders are able to 'eavesdrop' on conversations (Schertzer et al. 2009). In the right circumstances, this crosstalk can benefit both senders and eavesdroppers, but in other communities crosstalk provides opportunities for cheating, deception and exploitation. For example, the chemical signals or metabolites used for quorum sensing may be good to eat, and are valued by freeloaders belonging to other species, as nutriments. The free lunch ends when the target is attacked, and quorum-sensing is superfluous. Polyglot freeloaders prolong the quorum-sensing phase by circulating disinformation – underestimates of the virulent population (Sandoz et al. 2007; Williams et al. 2007).

Disinformation is also employed defensively (Bjarnsholt and Givskov 2007; Popat et al. 2008). Suicide bombers provide one more example. Pulmonary strep infections are promoted by the release of a toxin via self-destructive bursting (lysis). This would be a one-generation solution if all of the bacteria possessing this trait in a given community or species were to self-destruct on the first opportunity. In practice, only some potential bombers self-destruct. Wholesale self-destruction is avoided by biological individuality, also known as 'phenotypic noise':

> [Suicidal] microbes might be responding to differences in their personal quality: a moribund cell with nothing to lose will be more inclined towards committing suicide for the good of healthy neighbours. More sinister is the possibility that bacteria are manipulated into making the sacrifice … (Gardner and Kümmerli 2008, R1023)

## Part Three: Biofilms

Many bacterial species enclose their communities within 'biofilms'. They are densely populated communities, growing on surfaces, protected from antibiotics and predation by a thick cover made of secreted polymers,

and structurally complex, with intricate channels for delivering nutriment and disposing of waste. Biofilms are also ubiquitous: responsible for many acute and chronic infections, the degradation of implanted prosthetic devices, the contamination of drinking water distribution systems, and a multitude of industrial problems. Communal relations appear to be coordinated and cooperative, and an analogy is sometimes made between biofilms and multicellular organisms.

However, multicellular animals develop from a single cell that proliferates, and constituent cells are siblings, so to speak. Most biofilms are composed of cells from different lineages or species, and many species are genotypically diverse – a consequence of spontaneous mutations and lateral transfer of DNA between species. In these heterogeneous populations, cheaters proliferate, reaping the benefits of indirect reciprocity and altruism without incurring the expenses. Strong conflicts and self-interest compromise the biofilm's thickness and growth rate, and reduce resistance to antibiotics – a case of 'the tragedy of the commons', made familiar to us by neo-Darwinians (Claessen et al. 2014, 117–18; Nadell et al. 2009).

The structural and physiological complexity of biofilms gives the mistaken impression that they compose communities of coordinated and cooperative groups. '[Yet] biofilms can emerge without active coordination [and] species stratification and channel formation do not necessarily require that cells communicate with one another using specialised signalling molecules' (Nadell et al. 2009, 206). Biofilms and quorum-sensing systems seem impressive because bacteria were formerly misperceived as primitive and solitary. However, the systems operate over very short distances – just a few cell lengths – and, so, contrast with multicellular animals, 'where many types of differentiated cells communicate across the whole architecture to produce a highly integrated functional unit' (Nadell et al. 2007, 217).

Biofilms and multicellular organisms are certainly different from one another, but 'different' does not imply 'higher' and 'lower' or 'sophisticated' versus 'primitive'. Bacteria are not the progenitors of eukaryotic (nucleated) cells. Biofilms are not an early stage in a shared evolutionary pathway, but rather the product of a unique trajectory. 'Different' refers here to *different vital economies* – distinctive modes of production, distribution, exchange and consumption. Different means 'strange', not 'primitive', when mode of exchange includes self-transformation via lateral transfer of DNA, consumption includes predation, cannibalism, and self-sacrifice, and the biofilm economy incorporates an intercellular caste system:

> [T]he chemical environment within a biofilm often differs greatly at different depths . ... [a] nutrient in the liquid surrounding a biofilm may be consumed by cells in the outermost layers such that its concentration decreases deeper in the biofilm. Meanwhile, a product secreted by the cells in the biofilm will often accumulate to its highest concentration within the biofilm's interior. Given that many bacteria use multiple growth substrates and release numerous extracellular products, diffusion limitation can produce complex vertical and transverse chemical gradients, particularly when the secretions of some cells are consumed by others. ... These gradients, in turn, generate numerous microniches within the biofilm that can induce pronounced physiological heterogeneity simply because bacteria alter their behaviour according to local conditions. (Nadell et al. 2009, 211)

Neo-Darwinian theory argues that the proportion of cheaters in a community inevitably increases, from minority to majority, in the absence of regulatory mechanisms. Communal survival requires a modicum of cooperation: once the proportion of cooperators drops beneath a critical threshold, a community collapses. Biofilms have additional worries: starvation, desiccation, predation, viral infections (bacteriophages).

Yet death can be a pathway to resurrection, via a process called 'sporulation', in which bacterial individuals are transformed into spores that are then dispersed from 'towers' into the ambient environment, to develop into free-living (plaktonic) cells, that will eventually aggregate on surfaces, and mature into biofilms. It is not a simple matter, though: life and death decisions must be made along the way.

> Considerable research effort has been devoted to untangling the components of the signal transduction decision-making system that allows the individual cell to decide whether to wait, take a chance … or commit to sporulation. It is now understood that the cell decision follows careful sensing, advanced cell–cell communication using a variety of peptide pheromones … and elaborate information processing to assess information about the colony density, the collective progression toward sporulation, and the inclination to escape into competence. (Schultz et al. 2009, 21027)

Sporulation is an energy-intensive process and takes several hours. It is initiated while enough nutrients are available to complete the process. If other bacteria within the same niche continue to grow, there is the risk

that nutrients will be exhausted before the cells committed to sporulation have completed the process (Claverys and Håvarstein 2007, 225). The choice is further complicated by the need to set priorities. What is the best investment when voracious, bacteria-eating protozoa patrol the biofilm's periphery? Bacteria may respond by postponing sporulation, and divert the resources needed for building towers into the task of engorging the bacteria living on the biofilm periphery to create a cordon of bacterial cells of inedible proportions, larger than the predators. The process of engorgement is routinely enhanced through cannibalising altruistic members of the community.

Schultz et al. write about a decision-making system that *allows the individual cell to decide*, while the processes described seem to be coordinated collective activities (Claverys and Håvarstein 2007). About the same time, in an essay on 'molecular autonomous agents', Stuart Kaufman identified autonomous agents as systems capable of self-reproduction and necessarily self-organisation, and able to act on their own behalf, citing the example of 'a bacterium swimming up a glucose gradient' (Kaufman 2003, 1089). Kaufman's additional interest concerns the question of fit between a presumably panbiotic tendency to self-organisation and the central dogma of evolutionary biology, i.e. the primacy of selection. Moreover, these questions can be pushed still further, to consider how the emergence of molecular autonomous agents bridges a 'willingness' to self-organise themselves into multicellular systems (and into social groups). The juxtaposed claims are not necessarily contradictory, but they require elaboration – a concept or theory for the puzzle of the one and the many, a puzzle that pervades microbial societies.

## Part Four: The human microbiome

Ninety per cent of cells living inside the human body or on its surface are bacteria – 100 trillion bacteria. In 2007, the National Institute of Medicine (US) created a Human Microbiome project (HMP), funding research on the composition and diversity of the microbial communities inhabiting major mucosal surfaces of the human body – the nasal passages, oral cavity, skin, gastrointestinal tract, and urogenital tract – and research on the genetic metabolic potential of these communities.[2] I will use 'microbiome' in a restricted sense, to refer to the gut bacteria (enteric bacteria). While only a minority of these bacteria form biofilms, a useful comparison can be made between microbiome and biofilm societies. There are abundant and obvious similarities, but I want to begin with an

important difference, concerning the quality of 'containment'. Here, and throughout this chapter, I have retained the societal terms used by microbiologists. Containment refers to factors preserving physical borders or boundaries. The biofilm's boundary is a viscous polymer covering created by the resident bacteria. A biofilm protects its resident bacteria: its job is to keep external threats out.

The boundaries of the gut microbiome are ready-made, but not its contents. The human fetus is bacteria free, and acquires its first bacterial residents during vaginal delivery, a second wave in the course of suckling, and additional bacteria via contact with the ambient environment. In the process, the immune system is educated and matures. There are three competing views of how this happens. The traditional view is that 'the immune system is educated not to react to self and to react to non-self. [The] self is good and induces tolerance … Non-self, including microbes … are evil and elicit an immune response aimed at destroying non-self' (Eberl 2010, 454). The microbiome view is that the immune system is educated to be tolerant to self through a system of microbial pattern-matching.[3] The notion of self is modified: 'good' includes both the familiar, normal self plus its mutualistic microbes. The third view, now emerging, is that:

> [T]he perceived duality of mutualistic and pathogenic microbes, normal and altered self … represents extremes of a continuous reality. Microbes can express different levels of mutualistic or pathogenic properties and these levels can vary during interaction with the host. [T]he state of self and of immune responses … navigate between well-described extremes, and the most likely states are combination of these extremes. (Eberl 2010, 454)

All three views posit that the immune system plays a key role in containment – restricting the resident bacteria to the confines of the microbiome. However, it is the third view that emphasises the dual character of friendly microbes, the fact that even good friends can become dangerous threats. Once past the gut's epithelial wall, microbial friends become a source of sepsis, and potentially septicaemia. It is the strategy of containment that makes this unlikely. The innermost layer of the intestine is the epithelium, and contains specialised cells that secrete mucus to lubricate the passage of food. The sheer number of intestinal bacteria makes an occasional breach inevitable. The bacteria that penetrate this barrier are generally eliminated by macrophages. Bacteria getting through this barrier are engulfed by dendritic cells (DCs) and carried alive to the mesenteric lymph nodes where their identities (chemical signatures) are

decoded. A protective immunoglobulin IgA1 is released and distributed over the mucosal layer that coats the gut's epithelial cells. Thus a barrier is erected that neutralises the bacterial threat before the microbes can reach the cells (Hooper et al. 2012, 1269).

## Part Five: Bacteria's brain

The gut bacteria contribute to the production of neurotransmitters and neuroregulators integral to the development and functioning of the sympathetic and central nervous systems.[4] Gut bacteria communicate with the brain and nervous systems through multiple pathways: the circulatory system, the vagus nerve, and the neuroendocrine circuit (hypothalamic-pituitary-adrenal axis) that underpins the stress response. The pathways are bidirectional, but the mechanisms through which the gut bacteria receive and respond to incoming chemical signals is unclear.[5]

The bio-behavioural effects of gut–brain signalling are studied by comparing the behaviour of germ-free (gnotobiotic) mice with normal mice under controlled conditions. Germ-free mice exhibit low anxiety behaviour when placed in novel environments, for example, they show greater inclination to exploratory behaviour. Similarly, HPA axis arousal is less intense (measured via levels of corticosterone) when germ-free mice are put into stressful situations, such as maternal separation or physical restraint. Other efforts to study gut–brain signalling focus on the influence of specific bacterial species. These experiments alter the bacterial composition of the microbiome through dietary change, the introduction of probiotic bacteria or invasive pathogenic bacteria via faecal transplants etc., and the administration of selective endogenous bacteriocins. Although it is widely presumed that social relations within the microbiome – competition for binding sites on the gut wall, and competition for nutrients needed for growth – have differential effects on the host's behaviour, cognition and mood, it remains unclear how the underlying mechanisms can be studied experimentally. Consequently, conclusions regarding the microbiome's contribution to psychiatric disorders (depression, anxiety disorders, autism spectrum disorders) are based on correlations rather than causation.

The history of the microbiome is a chronicle of efforts aimed at connecting bacterial communities and strife to organ systems, physiological processes, and popular conceptions of selfhood and sensibility. This is the background for explaining the explosive growth in biological research,

science publications, journalism, and government funding focused on the microbiome. Thus, advocates for the creation, in the US, of a Human Microbiome project comparable to the Human Genome project (HGP) justified its enormous expense by arguing that the HGP, as it was originally conceived and executed, had been incomplete.

## Part Six: The social life of enteric bacteria

> Over the past 5 years, studies have linked our microbial settlers to conditions as diverse as autism, cancer and diabetes … This excitement has infected the public imagination. 'We Are Our Bacteria', proclaimed one headline in *The New York Times* … Companies offer personalised analysis of the microbial content of faecal samples, promising consumers enlightening information … Faecal transplants have been proposed – some more sensible than others – for conditions ranging from diabetes to Alzheimer's disease. With how-to instructions proliferating online, desperate patients must be warned not to attempt these risky procedures on themselves. (Hanage 2014, 247)

Popular interest in the human microbiome in North America remains unbounded, notwithstanding the scepticism of many researchers and dubious evidence of its salutogenic potential. 'Eat your way to health' is an old theme. The transgressions are new. Childbirth transformed into a bacchanalian rite of passage, in which a sterile fetus drinks deeply, through mouth and nose, of germs, dirt, and vaginal excretions, and emerges a viable human being. Woe to the uninitiated child (Caesarean birth): he will be punished with obesity. This is new. Ditto the vision of vindictive Gaia: 'Like ecosystems the world over, the human microbiome is losing its diversity, to the potential detriment of the health of those it inhabits' (Brody 2014). Who would have predicted the happiness of educated Americans following the discovery that 'we' (i.e. somatic cells) occupy only 10 per cent of our manifest bodies?

While these responses are worth ethnographic attention, I want to finish by calling attention to a significant absence. I began this paper with a theme developed in a recent issue of *Current Biology*: all life is social, in some sense collective.

The evolution of collective behaviours demands intrinsic phenotypic flexibility in the behaviours of individuals and groups in response to changing social and environmental conditions and mechanisms to

facilitate coordination among members of the collective (Ross-Gillespie and Kümmerli 2014). Brainless microbes satisfy these demands partly by quorum-sensing. The quorum-sensing systems favoured by bacteria rely on the diffusion of chemical signals and pooling information. To be more precise, the scientists are writing about *social information*: signals and/or cues generated by other individuals. By averaging across multiple potentially noisy informational inputs, the decision-makers (individual cells) acquire an accurate impression of their surroundings and neighbours and produce egalitarian decisions. Operations involve an intrinsic response threshold and local feedback. Once signal receptors are sufficiently stimulated, a group-coordinated shift in gene-expression is induced.

Adjustments in the signal threshold are geared to maximising adaptation to prevailing conditions. If the signal threshold is set too low, a premature collective response follows, and fitness drops at the level of the population. When set too high, it is difficult to mobilise an effective collective response. Shifts aim for either greater speed (lower threshold) or greater accuracy (higher threshold), and are produced, in the short run, via phenotypic plasticity and, in the long run, via selection (facilitated by lateral gene transfer). These effects have been observed via experiments and computer simulations.

Cooperation is impeded by conflicts of interest. Conflicts are less frequent in communities with a high degree of relatedness. Natural microbial communities involve interactions among individuals that vary widely in their relatedness to one another. The creation of disincentives for dissent and cheating helps to limit these conflicts. This solution presumes a decision-making mechanism anteceding the increased costs:

> Besides destabilising cooperative actions, and the collective decision-making processes that underlie them, conflicts of interest can also influence selection for different forms of decision making. When conflicts are relatively minor, and where information can be pooled fairly broadly (for example, small groups) it is easy to see how leaders could emerge – typically from among those individuals for whom different decision outcomes would have strongest effects on fitness – and how an initially democratic decision process could transition into a more autocratic one. Where more substantial conflicts of interest exist, meanwhile, democratic systems of collective decision making should be the most robust, since these give rise to the most accurate decisions (i.e. best-fit compromise across all individuals). (Ross-Gillespie and Kümmerli 2014, 7)

This social dimension of microbial life, and therefore everyday life in the human microbiome, is missing in the popular accounts. Moreover, it is likewise neglected in the published rationale for the Human Microbiome project. The project's defining technology, metagenomics, is creating a distinctively desocialised version of the microbiome. The project does not overlook social relations altogether: it is committed to understanding 'how the microbiome and human host interact to support health or to trigger disease'. However, the logically antecedent question is ignored: How do enteric bacteria organise themselves; how do they compete and cooperate with one another? The NIH subsequently established an Ethical, Legal and Societal Implications programme (ELSI) whose job is to address 'the new and unexplored issues which arise from human microbiome research'. However, once more, attention focuses on relations among humans and between humans and microbes.

## Conclusion: A question and less-than-satisfactory answer

Do bacteria really have a 'rich social life', as microbiologists claim, or does this idea falsely anthropomorphise a truly asocial nature, in a way reminiscent of the metaphorical 'cell state' pictured by Haeckel, Virchow and Spencer?

The social life claim is based on two propositions: a) bacteria behave in socially patterned ways, for example, cooperating with relatives, competing against strangers; and b) bacterial behaviour is guided by bacterial cognition, the capacity to recognise and choose among alternative possibilities. Proposition b accounts for the critics' scepticism. To be meaningful, 'cognition' must include decision making. According to sceptics, bacterial 'cognition' is a physico-chemical process, based on deterministic transduction of chemical signals, while 'decision making', in the ordinary language sense, requires a brain – at the very least, a nervous system. Bacteria possess neither. But there is another possibility: decision making can function through *stochastic intelligence*, a capacity bacteria possess.

> Life is a study in contrasts between randomness and determinism: from the chaos of biomolecular interactions to the precise coordination of development, living organisms are able to resolve these two seemingly contradictory aspects of their internal workings. Scientists often reconcile the stochastic and the deterministic by appealing to the statistics of large numbers … (Raj and van Oudenaarden 2008, 16)

Quorum-sensing, as described above, is one way in which bacterial social life reconciles the stochastic and the deterministic. The part played by 'leaders' in clonal communities – where individuals share a single genotype – is especially interesting in this regard. Notwithstanding the shared genotype, there is significant variation among individuals – a consequence of randomness in transcription and translation leading to cell-to-cell variations in mRNA and protein levels. During periods of collective stress, such as exposure to antibiotics, a small fraction of individuals become 'competent', able to take up DNA from the environment. Competence is a stochastic function (the result of randomness in transcription) that enables the leader to exploit noise (random variation) generated during quorum-sensing.

This chapter ends more or less where it began, with the puzzle of the one and the many. Who is the individual possessing stochastic intelligence? Is it the single cell (a bacterium), a biofilm (comprising a leader, species mates, and neighbours), or a super-organism (10 per cent 'host' and 90 per cent microbe, i.e. a 'distributed system')? Why should it matter? We are equally perplexed (since the time of David Hume) by decision making located in the brain and self-consciousness. The two puzzles are connected by stress and anxiety, and a neo-Darwinian imperative. Is there more?

## Notes

1. I have taken my title from a landmark volume on acephalous human societies, *Tribes without Rulers: Studies in African segmentary systems*, edited by J. Middleton and D. Tait (1958). See Theis et al. 2016 for an overview of the Holobiont concept.
2. The microbiome is inhabited by archaea (like bacteria, eukaryotes), viruses (including bacteriophages that infect bacteria), fungi, and protozoa. The HMP is focusing on bacteria.
3. Eberl (2010) describes two types of pattern recognition receptors (PRRs): microbe-associated molecular patterns (MAMPs) and pathogen-associated molecular patterns (PAMPs).
4. The gut bacteria are the body's main source of tryptophan, a serotonin precursor; and contribute to the production of major neuroregulators, integral to the development of the central nervous system and operations of the stress response: acetylcholine, GABA (gamma-aminobutyric acid), and BDNF (brain derived neurotrophic factor). Species of bacteria are likewise implicated in the production of dopamine and norepinephrine.
5. 'In the late 1920s, Walter Cannon, the founding father of the study of gastrointestinal motility, emphasised the primacy of brain processing in the modulation of gut function. It is now increasingly being recognised that the gut–brain axis provides a bi-directional homeostatic route of communication that uses neural, hormonal and immunological routes, and that dysfunction of this axis can have pathophysiological consequences' (Cryan and Dinan 2012, 701).

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# Chapter 6
# Biosocial Dynamics of Multidrug-Resistant Tuberculosis: A Bacterial Perspective

Jens Seeberg

> Humans have created an ideal environment for the development of antibiotic resistance (Orzech and Nichter 2008, 269).

## Increasing access to medicines

How may the spread of antimicrobial resistance to medicines for tuberculosis (TB) be understood if it is seen from the perspective of bacteria engaging with an epidemic of treatment? Moreover, how do new medicines and technologies reconfigure the biosocial dynamics of this particular epidemic, when implemented through underfunded public health systems?

A call was put forward during the 1990s and 2000s for universal access to existing and effective treatment against common diseases such as TB and HIV. Paul Farmer (2001, 2005) consistently and forcefully argued that the denial of such treatment was an expression of a global war against the poor, fought through mechanisms of structural violence. The call for global access to treatment is a strong moral imperative. Indeed, whether at the individual level when facing a patient or at the level of public health, the argument regarding access to life-saving medicine is well justified. Concurrently, new global funding mechanisms have come into place since the 1990s to support access to drugs. An example of this is the financing of the global TB control programme known as directly observed treatment, short-course (DOTS) through a combination of government and donor funding. In India alone, millions of patients were treated under DOTS, and by 2006, the government of India estimated that the lives of 2 million TB patients had been saved

(Government of India 2006). For this reason, DOTS was celebrated as a success in India during the 2000s. Two ticking clocks were placed on the website of the government's control initiative, the Revised National TB Control Programme (RNTCP): one for patients put on treatment and one for lives saved. These clocks have since been removed, though their traces remained visible for a long time afterwards, perhaps indicating a general lack of resources for the programme. Despite the emergence of new funding mechanisms globally, however, the effective improvement of health systems necessary to safeguard the quality of programmes such as DOTS and other medicine-intensive global health programmes did not materialise. Increasingly, healthcare is privatised, and state-funded health provision is under pressure, in India and elsewhere.

From its inception, the RNTCP in India had a substantial interest in the production of 'success stories' demonstrating the curability of TB with DOTS. Such messages were intended to decrease the stigmatisation of TB patients and stimulate passive case finding. Gradually, success stories became moderated a little by growing attention to treatment failure related to antimicrobial resistance. It was clear from the beginning that DOTS was a complex strategy that would also involve limited strengthening of the health system. Even if, in the later Stop TB strategy, this was given some attention as an area where investments were needed, the dominant line of thinking assumed that the general health system would somehow automatically be strengthened once scarce resources were flowing to the vertical TB treatment programme. This assumption disregarded evidence that the simultaneous existence of many competing vertical programmes resulted in a compartmentalised, fragmented and unevenly funded health system. So far, the priorities of dominant funding mechanisms, which see the solution to these epidemics in terms of physical access to pharmaceuticals and diagnostic technologies, have failed to address the biosocial dimensions of the disease. An understanding of biosocial dimensions would take as its starting point the lives of humans and of bacteria. In what follows, I shall pursue an understanding of the social co-existence of bacteria, their human hosts, and the anti-TB medicines with which both engage, in an analysis that seeks to incorporate three different scales across which social practices play out and interlink: the microbial, the human, and the global.

## Phages

The constant engagement of a bacterial cell with whatever inhabits its environment may at any point in time result in the cell's death, engagement

in relations of symbiosis, or resilience (i.e. resistance). From this perspective, the presence of anti-TB medicine in the host organism may be likened to the presence of viruses capable of infecting bacteria, so-called bacteriophages; or in the case of mycobacterial hosts, mycobacteriophages. A phage that infects Mycobacterium TB (M. TB), which causes TB, was first discovered in 1947, and hundreds of such 'TB viruses' have subsequently been identified. Once they are hosted by M. TB, they communicate their genetic material to the TB cell, affecting different aspects of its genetic code. Little is known about the complex relationship between phage infection and bacteria behaviour, but some phages seem to enhance the ability of bacteria to produce biofilm, while only a few have the potential to kill their hosts.[1]

Napier has argued in favour of a new sociobiology that prioritises 'organic relatedness over organic autonomy', where the self – the somewhat bounded organism – is as much xenophilic, i.e. seeking engagement with its organic environment, as xenophobic, defending itself against it (Napier 2013, 20; see also Young (this volume) for an overview of similar positions). A metaphor of travelling through an organic landscape could perhaps replace the traditional immunological metaphor of warfare as an appropriate trope for capturing this engagement of organisms, as in microbiologist Graham Hatfull's description of mycobacteriophages' search for suitable host cells:

> Thus, the observed phage diversity can be explained by assuming that wherever broad and diverse ranges of hosts are present, the phages can rapidly dance across the microbial landscape, using the hosts as 'stepping-stones'. Migration across this landscape requires that the 'stepping-stones' be spaced sufficiently close (genetically) to enable a host-range transition jump with either very few mutations or a gene acquisition event. (Hatfull 2014, 1)

Hatfull proceeds to talk about certain phages as 'merely accidental tourists in the Mycobacterium locale'.

From the perspective of the mycobacteria, such encounters with viral travellers constitute both communicative opportunities and risks. Whether a xenophobic or a xenophilic response would be advantageous is determined through engagement. For some mycobacteria, engagement with phages has been shown to influence their physiology in ways that increase virulence through expression of phage-encoded proteins or integration of the phage genome into the host gene, the so-called lysogenic

cycle, potentially affecting the ability to create biofilm and hence giving host cells with a particular phage infection a selective advantage (Hatfull 2014, 2). Another process of viral replication, known as the lytic cycle, allows the phage's DNA to exist as a separate molecule and replicate in a process that eventually kills the host cell when the cell membrane bursts and multiple new phages are released. Using a more conventional metaphor for the co-existence of bacteria and phages and the mechanisms of resistance to phage infection developed by the former and the counter-mechanisms to overcome resistance developed by the latter (and so on), Labrie et al. have described such processes as the 'arms race between bacteria and phages' (Labrie et al. 2010, 321); they describe the blocking of phage receptors as one of several resistance mechanisms developed by bacteria. Though an 'arms race' metaphor is open to differing interpretations, it seems to imply a war that can be won. I suggest that a 'traveller' metaphor takes us further in reflecting on organic interactions that involve risk and (evolutionary) development potentials, and hosts that are more or less welcoming along with guests that are more or less intrusive and influential and that sometimes become part of the family, so to speak. Less metaphorically, perhaps, we see that the long-term interaction of bacteria and phages has resulted in a flexibility for both that is crucial for their survival and continuous adaptation to ever-changing environments. Development of phage resistance is, therefore, a daily routine for bacteria, as are the other possible outcomes of the interaction, i.e. death and incorporation.

From the perspective of M. TB, anti-TB drugs have certain similarities to phages, but they are also dissimilar in important ways. Most importantly, the standard treatment drugs are not viral, i.e. they do not contain genetic material capable of replicating in the host cell, and the person under treatment must therefore consume them for a long period. If naturally occurring, phages contrast with the sudden and prolonged high concentration of engagement achieved through medical treatment and, in the case of combination therapy, the simultaneous presence of several antibiotics. Nevertheless, medicines may be considered similar to phages in terms of the natural response of the cell to develop, through mutation, mechanisms that enable the cell to resist the specific mode of operation of a given drug. Bacterial stress (for example, during antibiotic treatment) increases the mutation rate (Martinez and Baquero 2000). However, resistance can also occur by acquisition of resistance genes carried by other 'tourists', i.e. plasmids or transposons, across the microbial landscape, or by recombination of foreign DNA into the chromosome

(Martinez and Baquero 2000) further supporting the use of a viral metaphor for the spread of drug resistance among bacteria. The chances for development of resistance in M. TB to a single drug vary depending on the drug (Zhang and Yew 2009), but are invariably much higher than those of simultaneous development of resistance to several drugs. This is the logic behind the multidrug treatment regimes. Theoretically, if three or more drugs are present in the host body, the possibility of simultaneous development of drug resistance to all drugs is virtually non-existent. However, once resistance is developed, the genetic material of the TB cell has changed, and hence that drug resistance is replicated through standard processes of cell division. This allows for a new resistant strain of TB to spread, both within the human host (known as 'acquired' or 'treatment-induced' drug resistance) and, if it is pulmonary TB, to other people (known as 'primary' or 'transmission-generated' drug resistance).

Multidrug-resistant TB (MDRTB) is rapidly increasing worldwide. With approximately 25 per cent of the global TB burden, India is one of the most important geopolitical spaces for the TB epidemic and for the development of MDRTB.[2] In what follows, I shall discuss MDRTB in the context of the TB control programme in India.

## TB control in India

'Directly observed treatment, short-course' (DOTS); 'short' in this context means 6 months of uninterrupted treatment. The World Health Organization (WHO) developed this treatment regime in the 1990s in response to problems with patient compliance with the former treatment, which was of even longer duration and was unsupervised. A multidrug regimen, it was intended to control the risk of drug resistance. Even though WHO advocated DOTS as a globally uniform treatment strategy, in the event, it was implemented with some variations across countries; this chapter focuses on DOTS in India.[3] In 'directly observed treatment', a so-called DOT provider (DP) was in charge of the full amount of tablets for the duration of the treatment. During the initial two months' 'intensive phase', the patient had to visit the DP three times per week (this was known as intermittent treatment) and take the medicine under 'direct observation'. In addition to directly observed treatment and availability of the entire course of treatment from the outset, earmarked for individual patients, the DOTS regimen also included an extensive monitoring system. Each individual patient visit to the DP and each intake of drugs

were registered, and the information fed into a surveillance system that aggregated data at relevant administrative units up to the national level.

From its inception, and throughout high-burden countries, DOTS was a highly complex strategy that depended on the success of many simultaneous interventions at all levels of a given health system (Gericke et al. 2005). A vertical programme, it was semi-integrated with the existing health infrastructure and hence depended on the quality and stability of that infrastructure to achieve the desired effect on TB control. The programme rested on a calculation indicating that achieving a case detection rate of at least 70 per cent of all actual cases and a cure rate of at least 85 per cent could cut the TB caseload by half within a decade (Elzinga et al. 2004). This constituted a strong selling point for the adoption of the DOTS strategy as a major public health intervention by governments globally. In India, the National TB Control Programme had failed to manage the TB epidemic effectively during the 1980s and 1990s (Brimnes 2016). There was an urgent need for policy change, and WHO was advocating DOTS as an answer to the problem. This approach was eventually accepted by the government of India (GOI) and incorporated in the RNTCP, which was launched in 1993 as a pilot project. The programme was gradually scaled up from an initial coverage of 2.35 million people to cover a population of 20 million in 1996, the year in which World Bank funding was introduced, and a plan for rapid nationwide scaling-up of the programme was developed. Within the next 10 years, by March 2006, DOTS had been expanded to cover the entire Indian population, even if coverage as defined by GOI did not imply that all TB patients were treated under DOTS; rather, it meant that the formal DOTS structure was nationally accessible as per the norms established by the programme (Seeberg 2014).

## Contamination and configuration: TB treatment as an epidemic

Rosenberg uses the concepts of 'configuration' and 'contamination' to describe two distinct approaches historically used to explain the occurrence of epidemics (Rosenberg 1992). Configurationist explanations assume a normal health-maintaining steady state of 'climate, environment and communal life', and Rosenberg suggests that such 'holistic' explanations dominated before the appearance of medical knowledge about specific infectious agents (Rosenberg 1992, 295). Contamination

designates the idea of 'person-to-person contagion, of the transmission of some morbid material from one individual to another', or 'an event or agent that might subvert a health-maintaining configuration' (Rosenberg 295). Even if these explanatory models contrast, they are not mutually exclusive; rather, as Rosenberg points out, they weigh differently in different cases of epidemics and at different times. Using these concepts as analytical categories (Seeberg and Meinert 2015) rather than as contrasting types of explanatory models allows for us to explore the configuration of an epidemic of contamination of drug resistance (see also Seeberg 2019). Furthermore, if we adopt the perspective of TB bacteria, TB treatment in the age of global health becomes a pandemic of contamination that is potentially fatal for M. TB. Studying the configuration of this pandemic (i.e. global TB governance and its implementation in specific contexts) enables us to explore from a new angle, ways in which the bacteria have been able to transform into drug-resistant strands, seemingly successfully surviving the global health 'treatment pandemic'.

Due to its strong walls, M. TB is a very robust cell, capable of surviving in dry environments for years, and in air for days. Its cell walls have enabled it to develop a 'complex parasitic relationship with its host's immune system' and 'down-regulate its host's immune response, allowing the pathogen to protect itself from attack by the immune system and thus to survive in a latent state for decades' (Nightingale 2010, 167). It is this capability that explains how an estimated one-quarter to one-third of the world's population can be infected with latent TB, capable of subsequently producing disease if the immune system is compromised, for example, with HIV co-infection or malnutrition. As is the case with the TB cell's evolutionary relationship with phages, the cell's relationship to its human (or non-human) host is one of biological co-evolution. With the configuration of urbanisation from the sixteenth century onwards, the disease gradually changed from rare to epidemic (Nightingale 2010) because of the combination of high population density, poor hygienic conditions and widespread undernutrition. The relative disappearance of TB from the Global North and its epidemic proportions in the Global South can be seen as expressing global reconfigurations of these three factors, further fuelled by its syndemic relations to HIV (Singer 2009).

If the TB control programme creates, from a TB bacteria perspective, an epidemic of contamination, it is potentially a very serious one. DOTS used a combination of four drugs – Isoniazid, Rifampicin, Pyrazinamide and Ethambutol – in the first 2 months of treatment. If the medicines had the desired effect, demonstrated by a negative sputum test, the dose was reduced during the following 4 months of treatment

with only Isoniazid and Rifampicin, where the patient was given treatment to take home for a week at a time.[4] Isoniazid, Ethambutol and probably Pyrazinamide attack the cell wall, whereas Rifampicin inhibits the cell's ability to perform RNA (ribonucleic acid) polymerase (Laurenzo and Mousa 2011). If all these drugs are administered together, and for an extended period, a treatment-naïve TB cell has virtually no chance of survival, since it depends on mutation to develop the appropriate forms of resistance for each drug independently. Patients who resumed treatment after an interruption of 2 months or more (so-called 'defaulters') and relapsing patients were categorised as Category II patients; in these cases, intravenous Streptomycin was added to the regimen and intensive and continuation phases were increased to 3 and 5 months respectively, resulting in an additional 8 months of treatment. In spite of this chemical carpet-bombing of the TB cell's walls and interior, similar to a contamination syndemic (the mutually reinforcing dynamics of two or more concurrent epidemics in a population) (Singer and Clair 2003) with quadruple exposure to pathogens for the TB cell, multidrug resistance still happened; conversely, the reduction of incidence that had been calculated as the desired public health outcome (i.e. cutting TB by half in a decade) did not result. Figure 6.1 shows the trends over the period 2005–18 for notified cases of TB (the flat graph) and MDRTB (the rising graph, note: logarithmic scale) in India.

Estimated numbers are much higher than notified numbers, and so it seems that M. TB is so far able to adapt to this syndemic of anti-TB medicines. Keeping in mind Napier's call for a sociobiology that focuses

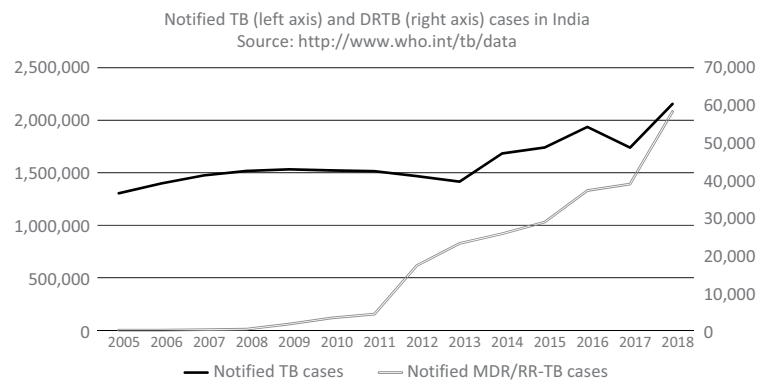


**Figure 6.1** Trends for notified TB and MDR/RR-TB cases in India. Data source: http://www.who.int/tb/data.CCBY-NC-SA 3.0 IGO.

on the communication between organisms, it seems that the TB bacteria engage in similar ways with drugs and phages, with outcomes that may be positive (resistance or adaptation) or negative (death), but in specific cases are unknown and perhaps unpredictable. To understand how the TB cell is able to resist contamination, so to speak, I return to the trope of configuration. How is the 'epidemic of anti-TB medicines' configured?

## Configuring the spread of TB treatment

Most public health studies on the occurrence of drug resistance under the DOTS programme either take a standard epidemiological approach involving the identification of risk factors for 'defaulting', or (more seldom) take a qualitative approach and ask 'defaulters' about why they have left treatment. 'Defaulters' constitute by definition the category of patients who have interrupted treatment for two or more consecutive months. A frequently held view on acquired drug resistance in TB in public health literature would state that MDRTB 'for the most part [is] due to inappropriate treatment protocols, non-compliance or inappropriate dosing schedules' (Laurenzo and Mousa 2011, 6). I shall return to inappropriate treatment below; here I focus on non-compliance. Given that DOTS, by definition, used correct treatment protocols and appropriate dosing schedules, it is hardly surprising that attention initially concentrated on the category of 'defaulters' in attempts to understand their 'non-compliance' or 'non-adherence'. For example, a hospital-based study in South India identified patients 'vulnerable to default such as males, alcoholics,[5] smear positive cases, and DOT being inconvenient' (Jaggarajamma et al. 2007, 130). The authors felt that 'Intensifying motivation and counselling of this group of cases are likely to improve patient compliance and reduce default' (Jaggarajamma et al. 2007, 130). Other study designs have allowed for a more nuanced discussion of the issue, and suggested that the category of 'defaulter' be reconsidered (Jaiswal et al. 2003), a revision of terminology that was embraced by WHO in its 'End TB Strategy' (WHO 2014b).

Seeing the issue from the bacterial perspective, and hence perceiving treatment as a contamination epidemic, makes it possible to ask a somewhat different set of questions. What is 'access' combined with 'non-compliance' in a global health perspective now becomes a question of exposure. A number of situations could offer TB bacteria some relief from exposure to the toxic treatment. As mentioned earlier, India had from the beginning decided to implement so-called intermittent

treatment, with administration of medicines three times per week during the intensive phase, whereas most other countries had implemented DOTS with daily medicine administration.[6] The reasons for intermittent treatment were economic and managerial, but the risk of adverse side effects was also reduced (Saltini 2006). It was cheaper to manage a system with patient–provider contact reduced to less than half that required for a daily regime. It meant, however, that missing one dose equalled missing close to 3 days' medication. If this happened regularly, bacterial exposure was reduced and the risk of Rifampicin resistance increased (Saltini 2006, 2089). Another cause of interruption of treatment was the gap that often arose between the intensive and continuation phases. After the intensive phase, the patient had to travel to the diagnostic centre for a sputum test. Whereas the distance between patient and DP was supposed to be less than 2 kilometres, the distance to the microscopy centre could be considerable, and it could be difficult to organise the journey due to work and social obligations. Even if the journey was made, there was no guarantee that health staff were available. With effective treatment, the sputum test would be negative (sputum conversion) and the patient would be shifted to the less aggressive 'continuation' regimen, whereas patients with a positive test would remain on intensive phase treatment. Depending on the stability of exposure during the intensive phase, this window between the intensive and the continuation phases established another systemic risk of interruption. The pressure to ensure that the patient went for the sputum test fell on the DP, adding to the need for a trusting relationship between DP and patient.

Furthermore, in many cases, the assumption that a trained DP would be within reach of any patient across the subcontinent was rather optimistic. For this reason, two emergency measures were routinely taken. One of these was 'spot training' of a relative or neighbour, who in place of a full day's DP course would be given a briefing on how to give the medicine, how to complete the patient card and whom to report to. This was not necessarily a less effective approach, since as many as 50 per cent of trained DPs at a given point in time did not treat any patients for years after their training was completed (Hjalsted 2003). If spot training was not possible, for instance, if no volunteers were available, a second measure was for the medicine box to be given to the patient, who would be given similar on-the-spot instructions. Faced with the alternative of denying sick patients treatment, dedicated frontline health workers who were used to 'improvising medicine' (Livingston 2012) in difficult situations in order to make sense of their work were squeezed between rigid programme guidelines and rough realities. Patient-administered TB treatment was often practised in

areas very far from functioning health clinics with trained staff. A study from Odisha – a state in India with a large population classified as 'scheduled tribes', who have historically been pushed into hilly and mountainous areas with poor infrastructure – found that in 2001, only 68 per cent of patients registered in the DOTS programme received directly observed treatment (DOT) throughout the intensive phase of treatment. One of the main reasons for not having DOT among patients even when a DP was available was 'reluctance to have nine tablets on an empty stomach in the morning' (AIMS Research 2002, viii). A comparison of 'community DOT' provided by health workers and 'family DOT' given by a relative showed that more patients completed treatment with family-based supervision and support (Newell et al. 2006). A study from Kerala, India, found that 27 per cent of those patients who were reported to receive observed treatment in fact did not and that they accounted for 86 per cent of treatment failures or relapses (Balasubramanian et al. 2000, 410). Given that approximately 70 per cent of registered TB patients in India were male and that the vast majority of DPs (80–90 per cent) were female (Hjalsted 2003), the idea that maleness could be constructed as a risk factor for defaulting as quoted above is hardly surprising. However, this observation should be placed in a context where it was often difficult for female DPs to operate and assume the authority necessary to personify a very paternalistic treatment system in a society with pronounced gender inequality. In addition, DPs without other health training frequently faced problems when trying to obtain the medicine from and otherwise interact with health personnel at the TB centre (Hjalsted 2003). The implementation of a programme that forcefully interfered with patients' daily lives in a strict treatment-cum-control regimen was highly dependent on local context and existing power structures to assert itself. In the fast and target-driven expansion of DOTS in India, such dynamics were ignored or assumed to be unproblematic. The speed with which DOTS was expanded and the necessity of disregarding local solutions to implementation problems in favour of easy-to-manage uniform policies pushed by the World Health Organization was itself an important part of the configuration. These factors created a context in which reports of dysfunctional health posts, untrained personnel and long-term vacancies at key posts in peripheral districts were highly unwelcome among state-level and national-level TB administrators who were engaged in the race against time to complete full DOTS coverage by March 2006 (Seeberg 2014). In many places, DPs and lab technicians were trained in large numbers, but the system's internal supervision and monitoring practices could not be uniformly sustained, at least not for an extended period

of time. The logic of the surveillance system focused on registering the moment at which the patient was supposed to swallow the tablets.

Hypothetically, one could imagine a different kind of monitoring system, one that not only registered 'missed doses' but that monitored the quality of the health system: days without the presence of a medical doctor or a lab technician due either to 'other work' (a euphemism commonly used for personal business elsewhere) or long-term vacancies; periods with defective microscopes; lack of fuel for supervisors to conduct field visits; or periods where the DP would travel to other places, and so on. This kind of workplace monitoring would have its own practical, ethical and social problems, and supporting an underfunded public health system seems more important than adding new control mechanisms. Still, it seems a valid point that the existing monitoring system was not designed to demonstrate the need to invest more resources in the public health system, and it failed to connect its structural shortcomings more directly to the phenomenon of drug resistance. The 'faults' of 'defaulters' were given privileged visibility by the monitoring system and therefore in policy discussions, especially at the district and lower administrative levels, where the blame for health system inadequacies was typically directed (Seeberg 2014). In this configuration, the DOTS-based 'epidemic of antibiotics' proved less fatal to TB bacteria than had been calculated, as the meeting with ground realities offered sufficient opportunities for M. TB to develop drug resistance.

If, despite the tremendous efforts and resources invested in the programme, the DOTS strategy failed to take into account the living conditions of and social dynamics between providers and patients on the ground, it also had another serious problem. The rapid expansion of DOTS did not take place in a context free from pre-existing TB treatment. On the contrary, in an Indian health system dominated by commercial health clinics, DOTS had primarily found its takers among poor patients in rural areas of India where government-run health clinics were fully or partially functional. In the large cities, government services at primary and secondary levels were largely absent and patients generally had to rely on commercial healthcare services. TB management in the commercial healthcare sector was, however, rather flawed. Uplekar and Shepard showed in 1991 that in Mumbai, 100 private practitioners prescribed 80 different regimens that were generally expensive and inefficient (Uplekar and Shepard 1991). In 1998 the situation was largely unchanged (Uplekar et al. 1998). This situation contributed substantially to the development of MDRTB in India (Udwadia 2001). The booming pharmaceutical industry's engagement with and monitoring of private

providers was the main driver of healthcare services in the commercial sector (Kamat and Nichter 1997, 1998; Seeberg 2012). The Indian drug company Lupin, with a dominant market share in anti-TB drugs, had a substantial influence on 'continued medical education' in the commercial sector, where doctors had few other options for keeping up to date with pharmaceutical developments. Ecks and Harper have shown that 'big doctors' (specialists, such as, pulmonologists) were opposed to DOTS because they considered the guidelines too inflexible for the management of individual patients: they saw a need to experiment in individual cases so as to reduce side effects and match dosage with the weight gain that typically accompanied successful treatment (Ecks and Harper 2013). General practitioners were less concerned with TB, since it was perceived as affecting only a small proportion of the cases they saw in their clinics. Therefore, they were less susceptible to the medical representatives'(MRs) 'education' about TB even if this, according to the MRs, might save doctors from engaging in malpractice (Ecks and Harper 2013, 266–7). The vast population of registered (or rural) medical practitioners (RMPs, often labelled 'quacks' by medically qualified doctors) also constituted an important outlet for Lupin's medical representatives, as for most Indian-based drug companies, even if these practitioners did not 'understand the quality' of the medicines (Ecks and Harper 2013, 267). While active TB infection was already disproportionally affecting the poor, the differential costs involved in consulting these practitioners clearly favoured opportunities for M. TB to develop drug resistance among poor patients, who had no option but to choose the short-term treatment of RMPs for economic reasons, unless they were enrolled in DOTS. Add to this the circulation of expired, substandard and spurious drugs in a potentially illegal medical economy with few or no quality checks in place among the non-specialised and non-qualified practitioners more often frequented by poor patients.

Especially in urban slums, it was difficult to implement DOTS (Seeberg 2013; Das 2015). Inhabitants had plenty of unpleasant experiences with state representatives and often lived under a general fear of eviction, another bureaucratic constraint that could lead to treatment delay or treatment refusal, since proof of residence was a prerequisite for assigning a DP (Seeberg 2013). Furthermore, primary-level government health services were virtually non-existent in urban India. This meant that the health infrastructure was insufficient to support DOTS (Seeberg 2012), working as it was against the systematic anti-DOTS campaign among practitioners in the commercial sector (Ecks and Harper 2013), further supported by MRs from companies who saw DOTS as a potential

threat to their business. In this context, with only around 0.25 per cent of medically qualified private practitioners involved, it was not surprising that the response of 'public–private mix', as a strategy to expand DOTS and control the unstandardised treatment regimes in the commercial health sector, had very limited success (Seeberg 2014). With a 46 per cent share of TB drugs in India, and with 74 per cent of the TB drugs consumed in India being dispensed by the commercial health sector and only 26 per cent by DOTS (Ecks and Harper 2013, 254), the dominant pharmaceutical company Lupin seemed to ignore the rise of drug resistance in the interest of short-term profit rather than engaging in a long-term collaboration with the state to promote DOTS. This apparent strategy was pursued despite the consideration that changes in global treatment regimens are likely to develop faster than any single drug company can adapt to such change, thereby creating space for new and competing pharmaceutical companies to become dominant.

From the perspective of the TB bacteria, it is obviously immaterial whether the host is engaging with drugs that pass through the commercial or public healthcare sector. From its perspective, this is one syndemic (Singer and Clair 2003) involving multiple contaminants distributed along socio-economic differentials among their hosts in their immediate organic environments. Viewing this as configuration rather than contamination, however, the political and economic separation of these sectors works to optimise the opportunities for TB bacteria to develop resilience. Conversely, this has a negative impact in the form of an escalating epidemic of MDRTB as seen from a human perspective.

## Multidrug-resistant tuberculosis in India

Multidrug-resistant tuberculosis is defined as drug resistance to at least two of the four first-line drugs used in standardised TB treatment. For an extended period during and after the expansion of DOTS, the GOI refuted that drug resistance among DOTS patients was a problem. Lack of access to diagnostic facilities to test for drug resistance allowed MDRTB to remain invisible. As these facilities became more accessible and with a growing number of alarming studies showing an escalation of MDRTB patients (for example, Almeida et al. 2003), the GOI eventually incorporated the so-called DOTS+ regimen in the TB control programme, following a 'consensus statement' issued jointly by the government and leading TB research centres in India on MDRTB in 2007 (Engel 2013). DOTS+ was not only much more expensive; with a treatment duration

of 2 years of chemotherapy, its management added exponentially to the complexity of an already complex public health intervention.

Furthermore, in India, because access to drug susceptibility testing during the 1990s and 2000s had been poor, it was generally not known whether drug resistance or other factors caused treatment failure. Towards the end of this period, however, upgrading of laboratories and availability of medicines for patients who tested positive for drug resistance, classified as CAT IV treatment, changed this situation in parts of India. This also led to dramatic changes in the figures involved: an estimate of 99,000 new MDRTB cases annually by 2011 was quoted by a leading national expert (National DOTS+ Committee 2011). Compare this with figures saying that 4,217 patients had been placed on CAT IV treatment by end of 2009, of whom only 756 were alive 12 months later. The rapid expansion of the DOTS+ programme (meanwhile renamed to 'programmatic management of drug-resistant TB' (PMDT)) is visible when these figures are compared with the STOP TB India country profile for 2012, with 64,000 notified cases of MDRTB and 14,143 (22 per cent) patients started on MDRTB treatment (WHO 2014a).

The challenges posed by this iatrogenic epidemic for public health are formidable. Not only are individual patients and their families forced to realise that the kind of TB they have is very difficult to treat successfully and likely to cause individual death, household disaster and community-level distress. The rise of MDRTB turns the image painted by the commercial healthcare sector of DOTS as a failed government programme into a self-fulfilling prophecy, even if the commercial sector contributed substantially to the development of drug resistance.

Lock and Nguyen have pointed to the 'military-like organisation' (not to mention, rhetoric) adopted in large-scale public health campaigns developed in continuation of colonial medicine in Asia, Africa and Latin America (Lock and Nguyen 2010, 153). DOTS, with its strongly hierarchical organisation and emphasis on disciplining both patients and peripheral providers through supervision, monitoring and 'motivation', was an example of this. With its near-exclusive emphasis on drug delivery, the system was a carefully designed attack on TB bacteria. Patients were at best passive vessels through which the medicines had to pass, at worst obstacles to the success of the attack due to epidemiologically constructed risk factors of non-compliance such as being uneducated or consuming alcohol. Gradually, however, this medicine-centred approach was seen to conflict with rights-based approaches, which began to influence discourses about healthcare delivery globally. In particular, the need to address the TB–HIV syndemic brought into closer contact two

treatment systems that had hitherto viewed the issue of patient rights very differently. In India, confidentiality regarding information about TB patients was not routinely maintained at the community level; anybody in a village would be able to point a treatment supervisor to the house of a TB patient. At the same time, the discrepancy between policy changes and actual implementation was increasing, since 'policy translation' is a time-consuming process of negotiations, adaptations and (un)learning. Hence, while DOTS was rapidly being scaled up in India under the initial strategy, the then-new STOP TB strategy was being launched in Geneva in 2001. As DOTS reached national coverage in India, the Global Plan to Stop TB 2006–15 was published, calling for 'human rights imperatives' to be incorporated. However, the route from policy changes made in Geneva to the practising of TB treatment in a remote Indian village is very long.

Harper has pointed to a growing tension between problems with drug resistance and the patient-centred approach as advocated by the STOP TB partnership (Harper 2010). This tension was even more pronounced in connection with extensively drug-resistant TB (XDRTB), where additional resistance to second-line drugs made the disease untreatable in most settings. The dramatic rise in drug-resistant strains of TB created a situation where not only the prognosis, but also the rights of patients could vary depending on the type of TB, while it remained difficult in some contexts to determine the existence and extent of drug resistance.

Disregarding the classificatory issues mentioned above as well as the other barriers to treatment initiation that sometimes occur with standard TB, all patients identified by the DOTS programme were presumably placed under DOTS treatment. According to the Patients' Charter for TB Care, patients have a right to free and equitable access to services, including treatment, care and information; and they also have the responsibility to comply with the prescribed treatment plan. However, in the face of MDRTB and XDRTB, documents originating from WHO have begun to discuss more restrictive measures, including a return to isolation practices and the consequent risk that such measures could jeopardise the treatment programme as a whole and add to the stigmatisation of patients (Harper 2010, 210).

## Resistance-driven technologies

The DOTS+ strategy seemed unduly optimistic because it was essentially based on an idea of 'more of the same', i.e. more toxic drugs for a four-times-longer period compared with the regimen that had failed in the first

place. Dr Mel Spigelman, President and CEO of the Global Alliance for TB Drug Development (TB Alliance), talking in 2014 about the promises of a new drug combination going into phase three clinical trials, stated:

> Many of the problems with today's MDRTB treatment are due to the fact the regimens were assembled as an emergency reaction to the problem – an approach of treating patients with the 'kitchen sink' of available drugs to find something that works [and] an approach whereby you throw what you have, flawed as it may be, at the problem and hope for the best. (Prasad 2014)

This may be seen as a somewhat arrogant description, given the substantial resources that had gone into convincing governments that DOTS+ was the necessary answer to the MDRTB epidemic and into the subsequent revamping of the programme in order to enable the system to apply this 'kitchen sink approach'. Nevertheless, Spigelman illustrates that the response to the crisis of MDRTB was one of more drugs, rather than one of addressing health-system failures leading to the development of drug resistance in the first place.

One would like to share the optimism that the answer to drug resistance is new drugs: that we can solve the problem with yet another technological fix. One of the most prominent candidates for such new treatment, according to Bill Gates in 2014, and depending on the outcome of phase three trials partially funded by the Bill and Melinda Gates Foundation, was a new combination therapy known as PaMZ. This regimen was linked to promises to reduce treatment periods for TB to 4 months and for (susceptible) DRTB to 6 months, with fewer tablets to take for patients (Gates 2014). Both were important dimensions of potentially less troublesome treatment regimens. But two years later, TB Alliance decided to close enrolment to the trial in favour of a more promising Bedaquiline trial known as BPaMZ. Important as new anti-TB medicines are, they are also goods circulating in the economy of technological hope; by contrast, improvements of the public health infrastructure with well-established positive effects remain underfunded.[7]

The role of the phages in the above discussion was to launch the idea that from a bacterial perspective, anti-TB medicines could be seen as an epidemic of contamination, that the bacteria had to relate to in order to either die, survive as self, or transform into a new (drug-resistant) strain. However, phages too may become medicine. The landscape of phages could constitute another potential frontier for treatment-orientated developments. Phage-based therapies have been tested in treatment of

MDRTB patients in some countries of the former Soviet Union, where the breakdown of the health system in the wake of the collapse in 1989 of the state, along with abysmal conditions and treatment practices in prisons, resulted in widespread drug-resistant TB (Farmer 2001). Phage therapies have the theoretical advantage over standard antibiotics that they target specific bacteria and, therefore, do not have the generalised negative impact on the bacterial fauna that antibiotics have; indeed, for the same reason they are self-limiting – they can only exist in the body for as long as the host cell is present. Problems include high immunogenicity that may result in their rapid clearing by the body, as well as the risk of production of high levels of endotoxins from lysed bacteria.[8] However, addressing such biotechnical issues is generally not considered interesting by a pharmaceutical industry that is nervous about intellectual property rights, given that phage therapy has been used in the public domain for a century and that individual phages are unlikely to be patentable (Clark and March 2006). Thus, a major obstacle to pursuing this potentially less harmful and more specific (although, so far, not very effective) treatment directed at a major health problem is that it does not fit the dominant business model of present-day global health financialism (Erikson 2012, 2015).

Using the standard treatment in environments with high but unknown levels of Rifampicin and Isoniazid resistance can lead to the so-called 'amplifier effect', whereby resistance to the other first-line drugs develops faster (Harper 2010), since the effect of having a combination of four drugs in this situation is significantly reduced. For this reason, the difficulties involved in testing for MDRTB combined with a uniform approach to DOTS implementation in a context such as India, in which most commercial-sector TB treatment is insufficient, has in itself potentially contributed to fuelling the MDRTB epidemic. Therefore, WHO approval in 2011 of a new technology to rapidly test for resistance to Rifampicin, known as Xpert MTB/RIF, which reduces the time for such testing from months to hours, was met with high expectations. The machine was designed for district-level implementation and was rolled out worldwide with support from USAID and the Gates Foundation, among others. The number of machines distributed in this approach has become a measure of success in itself. As pointed out by Adams, global health 'envision[s] a world in which, interventions can be mapped out as problems of scale and measurement (or specifically as counting practices) rather than as problems of custom, culture or national political will' (Adams 2016, 6). Riding the hope of improved TB control, such interventions allow for the continuation of an exclusively pharma-technical

understanding and management of what should in fact be regarded as a biosocial complex, with very selective and specialised 'vertical' support mechanisms to health systems in dire need of general strengthening (Biehl and Petryna 2013).

## Between nature and culture

The initial treatment standards of DOTS, with at least 70 per cent case detection and 85 per cent treatment completion, held out the promise that the caseload of TB would be reduced by half in a decade. This bioeconomic calculation shaped the projections of a regimen onto the complex dynamics of daily living for TB patients, health providers and bacteria alike. Among the many thousands of people involved in TB treatment globally, two interpretations of these standards can be imagined. One interpretation sees such targets as minimal quality criteria that must be fulfilled by any TB control programme. However, an alternative interpretation sees these as programme targets to be achieved. The two interpretations thrive alongside one another, even if target-orientated systems tend to favour the latter. A central question concerned the remaining 15 per cent of patients whose treatment completion was, so to speak, outside the target. The production of so-called 'defaulters' was a by-product of this target (Seeberg 2014), explained through the projection of certain characteristics (for example, being male, alcoholic, uneducated) onto systemic programme failure. For many years, this contributed to the configuration of the MDRTB syndemic by establishing a reservoir of TB cells that had better chances of developing drug resistance among those human hosts least able to follow the standard TB treatment, much less treatment for MDRTB.

From the perspective of the TB cell, medical treatment is a potentially fatal source of toxic contamination. The DOTS programme was a pandemic of such contamination, configured in particular ways that varied according to context. I have focused on India; but within India, configurations of DOTS varied across state and district boundaries, social classes, castes, gendered inequities, urban and rural settings, households, and individual patients, as well as density and performance of both government and private-for-profit providers. The projection of DOTS as a universal TB control programme and its rapid expansion in need of a one-size-fits-all logic was blind to the political economy of which it was itself a part. The relevance, if not the existence, of all these variations was forcefully denied. Revised global and national TB control strategies may have strengthened their focus on both DRTB and patient rights in certain

limited ways, but in contexts of serious resource constraints in government health facilities as well as in the households of most TB patients, it is likely that M. TB will continue to find successful ways to engage with the pandemic of medical contamination. Indeed, in this Waddington-like landscape (see Lock, this volume; Petryna, this volume), it seems likely that TB cells will continue to produce drug resistance faster than biomedicine can 'mutate' into new drugs and renew the efficacy of treatment. From this perspective, new drugs – and global access to them – may buy some time for humans in the ongoing engagement with bacteria such as M. TB. Biomedical optimism holds that this time will be sufficient for biotechnology to develop new vaccines of high potency, thereby solving the problem of antibiotic drug resistance en route to 'End TB'. While we wait to see what is on the 'blindsided' fold of this hopeful horizon (see Petryna, this volume), beginning to understand the biosocial dimensions of TB could help us to prepare better for yet another disappointment, perhaps even to learn from past failures about how to take the life circumstances of patients, providers and bacteria seriously when trying to help the former.

## Notes

1. The latter have inspired therapeutic use of mycobacteriophages against TB, but this remains difficult and controversial and is so far only approved in medicinal form for treatment of MDRTB in Russia and Ukraine. Recently, more attention has been given to the diagnostic potential of mycobacteriophages in detection of drug-resistant strains of TB.
2. Multidrug-resistant TB (MDRTB) and extensively drug-resistant TB (XDRTB) are sometimes grouped as DRTB, which is any form of drug-resistant TB.
3. Certain aspects of DOTS have also changed over time.
4. Earlier during the DOTS programme, three drugs were administered during the continuation phase.
5. An 'alcoholic' in India is not necessarily a person who has a dependency problem; often, it is a label conveying moral disapproval of any person who consumes alcohol, irrespective of the frequency and amount of intake. While often used among DPs and treatment supervisors in programme implementation, the concept is rarely defined, even when used in scientific articles about 'defaulting' in India.
6. Recently, this was changed to a daily treatment regime in the national TB strategy, even if this change takes time to be fully implemented.
7. Bedaquiline has subsequently proven to be an important new drug in the treatment of DRTB.
8. Lysis is the breaking apart of the cell wall and subsequent expulsion of cell content.

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# Chapter 7
# When Sickness Comes in Multiples: Co-morbidity in Botswana

Julie Livingston

## Introduction: Situations of complexity

Biology is often assumed to determine much about how illness and medicine are experienced. Yet what are we to make of situations in which biology points in multiple directions simultaneously? Botswana, like many places, is rife with co-infection and co-morbidity. The complexity is overwhelming. Simultaneous epidemics of tuberculosis (TB), HIV/AIDS, and cancer are deeply entangled and fuelling one another in this small Southern African nation. There are also ongoing epidemics of diabetes and hypertension to consider as well (Young et al. 2009; Haregu et al. 2012).[1] The situation is creating great challenges for both patients and their clinicians. They are seeking diagnosis and treatment in a health system whose institutional and intellectual architecture was to some extent designed to separate these three disease categories even as health planners and clinicians alike recognise how TB, HIV, and cancer continually clot back together, aggregating in the human body, clinical thought, and the social imaginary. The challenges are compounded by the potential for a silent or latent stage of each disease, the nature of AIDS as a disease of co-infection, the plurality of disease contained under the rubric of cancer, the historical freight of TB in the region, and the dissonance brought by the relative novelty of cancer in the country.

This kind of complex epidemiological landscape calls our analytical capacities into question. It troubles disease-centred social and medical science. It is local biology that at once threatens and reveals the taxonomic project at every level of iteration (see Lock and Nguyen 2010 this volume for an extended discussion of local biology).

It is not that disease specificity, that legacy of the bacteriological revolution, is absent entirely. Historians use the term 'disease specificity' to refer to a fundamental transition in medical reasoning that took place over the course of the nineteenth century. Charles Rosenberg (2002, 242) explains: 'In traditional [Western] medicine, disease concepts were focused on the individual sufferer. They were symptom orientated, fluid, idiosyncratic, labile, and prognosis orientated. Diseases were seen as points in time, transient moments during a process that could follow any one of a variety of possible trajectories.' By the early twentieth century, this idea had given way to 'the more abstract notion of disease entity as ideal type abstracted from its particular manifestations. A legitimate disease had both a characteristic clinical course and a [discrete, causative] mechanism.' However, while this sense remains, the presence of co-morbidities mean that the complexities of experience must be continually and artificially disentangled and sorted along biological, institutional, and intellectual grids in order to support such analytics. Clinical decision making around drug and radiation dosage, timing, and interactions necessitates great care in a medical system that is overwhelmed by the volume of patients and their biological intricacies. The stable, normative biomedical body within which disease is imagined, is not available. Nor are the ontological certainties that separate diseases from one another. In some cases, the ontological barriers make little sense: Kaposi's sarcoma (KS) in women is so extremely rare that it is almost thought not to exist without HIV, so are these two diseases or one? However, the political, economic, moral, and institutional projects that arise around specific diseases continue to matter tremendously.

Here is a quick glimpse at what that complexity looked like 10 years ago, in January 2007. At the time I was working as an ethnographer in the oncology service in Princess Marina Hospital, Botswana's central referral hospital, located in the capital city, Gaborone. I made the following entry in my field notes.

> A woman arrives dizzy and weeping. We see her sitting on the floor by the waiting bench and Dr P, the oncologist, has her put into a bed. She is *very* miserable. There is a man accompanying her. Is this her husband? Brother? She has HIV. Her CD4 is 251 and she is not yet on antiretroviral therapy. They have been treating her for TB for one month even though she has two purple KS lesions in her mouth and a big one on her arm and her lung x-ray shows the symmetrical, butterfly shaped pattern that is typical of KS. Dr P does a fine needle

> aspiration from the swelling in her neck to see if maybe she also has non-Hodgkin's lymphoma, but meanwhile, given the urgency of her lungs, will begin chemotherapy for the KS.

Or another from that same month.

> A man arrives on a stretcher. It turns out this patient is a nurse. He is in his late 20s and has HIV, TB, and KS – three wasting diseases. He is gaunt. He arrives from one of the provincial hospitals via the dental clinic, brought by Dr O, the maxillofacial surgeon, who wants Dr P to have a look. This patient has defaulted chemotherapy twice and he has big KS lesions inside his mouth, Dr O explains. No. The nursing assistant who has accompanied the patient from the provincial hospital corrects Dr O. This man has been hospitalised since June so it can't be his fault if he 'defaulted'. Now he is being referred by the doctor at the provincial hospital who is asking for a resection. But, as Dr O says 'No way – you can't cut KS out, it will bleed like mad' (KS, like other sarcomas is a very vascular cancer). Dr P agrees. They are frustrated with the doctors back at the provincial hospital, as is the nursing assistant. The patient will need to begin chemotherapy for a third time. The next day he was back, now accompanied by a nurse. It turns out he has multidrug-resistant TB (MDRTB). Dr P says to put him outside on the veranda where the ultraviolet light from the sun will kill the bacteria, while he waits for his chemo, but no one does it. Instead the stretcher is in the crowded hallway where cancer patients sit waiting for their chemotherapy and clinic appointments.

As you can see, some patients arrive in Botswana's oncology ward suffering from HIV, KS and TB. Some patients have been on TB treatment for months to no avail, before they are able to get the cancer in their lungs diagnosed, while others have to let their cancer wait while hopefully their TB and HIV are brought under control enough to give them the strength to undergo chemotherapy. Some patients have scar tissue in their lungs from previous TB infections, which increases their susceptibility to lung cancer (Vento and Lanzafame 2011). Sometimes the oncologist (who in the time of my research also served as the ward cytologist) finds lymphoma cells and TB bacilli in the same lymph node. Some HIV patients are co-infected with cancers, meaning they have multiple malignancies at once and of course some patients have cancer and TB but not HIV.

This chapter uses the particular vantage point of the cancer ward to try to understand how the meaning of co-morbidity and the densities of entanglement between HIV, TB, and cancers shift over time and across scale in this context of intersecting and accumulating epidemics. Epidemic multi-morbidity challenges the institutional capacity of the health service, the intellectual and technical capacity of hospital and clinicians, and the social, emotional and existential capacities of patients and relatives. In this way, it provides a key site for elucidating biosocial complexities and the need to refuse any false separation between nature and culture (see Lock, this volume) at all scales of analysis. For example, in the case of co-morbidity in Botswana, ethnographic attention to the medical institution as social environment further reveals contradictions between biomedical reasoning and the institutional organisation of both the hospital and larger health system. The biology with which the co-morbid patient lives is in contradiction to the environment designed to heal her. Ethnographic methods reveal the dilemma of the biosocial patient and the limits of the biological purchase of the clinician.

In what follows, even as I pursue the logic of co-infection, and given that approximately 40 per cent of the patients who arrive at the cancer ward are HIV negative, I also want to push a bit against an easy assumption that HIV is the index disease around which TB and cancers appear as co-morbidities (Valderas et al. 2009). While the production of knowledge (not to mention the political and funding impetus) in Botswana is to some extent organised around HIV, and while there is great truth to understanding HIV as a disease of co-infection, a model that overly privileges HIV is too limited to capture the complexities on the ground. Viewing cancer in Botswana mainly as an epidemic of co-infection risks subsuming the politics of oncology within those of HIV, even as they point in somewhat different, if overlapping directions. Cancer (like TB) asks us to think about labour migration in terms of occupational health and not only as the historical structuring force behind contemporary sexual and care-giving norms. It points to questions of toxicity and environmental health and cancer shifts the economic dynamics of the pharmaceuticalisation of public health (Biehl 2007).

I also want to push back against an assumption that co-infection, rather than co-morbidity is what matters. The majority of diabetic patients in Botswana are also hypertensive. While this relationship is often explained by its predication on shared risk factors (obesity, physical inactivity) what are the results of diabetic and hypertensive co-morbidity? What meaning does this articulation have for the patient who must attend two clinics, manage two pharmaceutical regimes, etc.? Or, given that not

all cancers have an infection component, what might it mean to rethink our taxonomy of infectious versus non-infectious disease? How might upending taxonomy help us to contemplate the presence of HIV in patients on antiretrovirals? These are persons whose viral load is contained so well as to be negligible in terms of transmission, even as the effects of the drugs themselves are somatic and enduring, and whose sexual activity nonetheless proceeds under the sign of HIV. What if as a thought experiment, and given the high rates of diabetes in Botswana, we reimagined this epidemiological landscape as one united around metabolism, tumour necrosis factor and wasting, rather than privileging the paradigm of infection? Or what if we rethought diabetes and hypertension as an epidemiology significantly determined through vascularity rather than through obesity? What happens if we triangulate dyadic diabetic and hypertensive co-morbidity through HIV, recognising that HIV infection raises rates of both? Might foregrounding co-morbidity open new sightlines in aspects of disease and illness that are currently overdetermined by the infectious disease paradigm?

Such thought experiments abound once one gives them free rein. What I am suggesting is that by paying attention to patient experiences and to clinician's frustrations at the contradictions that they must navigate, one finds places where the human body overspills or does not quite fit biomedical categories. These experiences can thereby be the basis for biomedical theorisation or question raising. As the editors of this volume observe in their introduction, and as the chapters demonstrate, anthropological perspectives on biosociality can speak to and resituate biological inquiry and practice in vital ways.

Botswana is a middle-income country with an agentive and forward-thinking ministry of health. For nearly 50 years, the post-independence state has steadily invested in infrastructure and social services, developing capacity in their system of universal healthcare. However, Botswana is not without its problems. While the GDP has gradually risen over the past four decades, the United Nations Development Programme (UNDP) estimates that about a third of Batswana (as citizens of Botswana are called) live below the poverty line, as the gap between rich and poor expands across the globe (Republic of Botswana and United Nations 2010). Quality of care and capacity remain a problem as the health system struggles to keep up with a challenging national epidemiological profile. Human resources and technological capacity are uneven and strained, and as in many medical systems, bureaucratic requirements often hamper delivery of efficient, effective care. Nonetheless, given the degree of state commitment to health, in recent years Botswana has become one

site in the region where new health policies and clinical modalities are developed and piloted, including most notably, the first public antiretroviral programme on the African continent. From Botswana, we can begin to see the thicket of intellectual, infrastructural, technical, and social challenges posed by the complicated relationship between ongoing epidemics of cancer, HIV, and TB.

I observed the brief scenes described above only 5 years into the start and scale up of Botswana's public antiretroviral programme. From its inception in 2002, the national programme triaged enrolment on antiretroviral therapy, to ensure that the sickest patients were covered first and then gradually scaled up from there. In 2007, the criteria for initiating Highly Active Antiretroviral Therapy (HAART) for a Motswana patient with a confirmed HIV diagnosis, were a CD4 count of 200 or below or an AIDS defining condition as established by the US Centers for Disease Control (CDC). In 2008, the threshold was raised to a CD4 count of 250 (and has continued to scale up to the current level of 350) and a shift was made from CDC clinical staging to WHO staging. In both staging systems, the presence of KS, invasive cervical cancer, non-Hodgkin's lymphoma, and/or TB (pulmonary or extra-pulmonary) indicated that HAART should be initiated regardless of CD4 count, though as we can see from my ethnographic vignettes, in practice this was not always done.

January 2007 also marked 5 years into the opening of the cancer ward and the beginnings of public oncology care in Botswana. The Botswana Ministry of Health had anticipated that the new antiretroviral programme would amplify the effects of HIV/cancer co-infection and so they planned accordingly. As HIV undermines the immune system, it makes patients more susceptible to a range of virus-associated cancers – most notably KS, non-Hodgkin's lymphoma, genital cancers, head and neck tumours, and other lymphomas. Before antiretrovirals were provided, AIDS patients with these cancers often died fairly rapidly from other opportunistic infections. But now as patients were put onto HAART, they began to survive longer, but with a new set of complications brought by their cancer. Experience in the US also shows that patients who do not have a cancer when beginning their antiretroviral treatment, nonetheless appear to develop cancers at higher rates over time even if they remain on antiretrovirals (Shiels et al. 2011). Botswana's lone oncology service was set up in a separate part of the central referral hospital from the Infectious Disease Care Clinic (IDCC) (as the HIV clinics in Botswana are called), and yet in some sense also as a response or supplement to it.

## Botswana's epidemiology of co-infection

Since the mid-1990s, Botswana has had one of the highest rates of HIV prevalence globally. A national survey in 2008 indicated an HIV prevalence of 17.6 per cent among the general population and a 40 per cent prevalence among people aged 30–44 years. In 2009, an estimated 331,000 people were infected with HIV, and there were over 8,700 HIV/AIDS-related deaths, and an estimated 18,000 new infections annually in this nation of 2 million citizens (Republic of Botswana 2011, 6). TB rates have also been consistently high since the mid-1990s. In 2008, Botswana had the sixth highest TB rate globally (536 per 100,000). As part of this unfolding epidemic, the rates of multidrug-resistant TB (MDRTB) are also rising, with a reported 'increase in new cases of MDRTB from 0.2 per cent in 1995 to 2.5 per cent in 2008' (Republic of Botswana Ministry of Health 2011, 8). Meanwhile, rates of cancer are also on the increase. Botswana has been building its cancer registry for the past decade, but its capacity for diagnosing and counting cancers remains much thinner than the epidemiological apparatus necessary for counting TB and HIV. Therefore, figures for cancers are necessarily more tentative than those for HIV or TB. Nonetheless, we know that 8,494 cancers were diagnosed between 2003 and 2008 (Dryden-Peterson et al. 2012; Suneja et al. 2013). We can be fairly certain this is an under-reporting of the true burden of cancer in the country.

A dense picture emerges from tracing connections between these figures. In a revealing limitation of logic in the health system (one I am told that the Ministry of Health is actively seeking to change), I could not find figures for TB/cancer co-morbidity, or for TB/cancer/HIV multi-morbidity, only for dyadic co-infections with HIV.[2] Recent, preliminary studies suggest that over 60 per cent of Botswana's cancer patients are co-infected with HIV (Dryden-Peterson et al. 2012; Suneja et al. 2013). They also suggest that even as patients are initiated onto HAART with relatively higher CD4 counts (remember the rise from 200 to 350), high rates of cancer persist. While rates of KS are dropping slightly, those for non-Hodgkin's lymphoma and HPV-related cancers have risen.[3] Meanwhile, epidemiological research in Botswana suggests HIV co-infection rates of 60–80 per cent in patients with active TB.

'Moreover,' researchers in Botswana have noted, 'the clinical presentation and natural history of TB differs between HIV positive and negative individuals. People living with HIV are more likely to be sputum

smear negative and have atypical clinical and radiographic evidence of TB disease, especially with advanced immune suppression. Treatment of patients with TB/HIV is also challenging, due to the frequency of immune reconstitution inflammatory syndrome (TB–IRIS), drug interactions and toxicity' (Republic of Botswana Ministry of Health 2011, 9). The same could be said for atypical clinical presentations of cancers in HIV positive people as well as the problem of drug interactions and toxicity. This is an epidemiology that resituates the 'normal' body.

The situation in Botswana is this. There are three epidemics at present: TB, HIV/AIDS and cancer. One of these epidemics is emergent (cancers). One is the resurgence of a long-standing problem (TB). One is an epidemic of co-infection (HIV) that acts as an accelerant and an amplifier of the other two, even as it generates an unstable clinical profile among co-infected patients. Meanwhile the other two (TB and cancers) also enjoy a synergy independent of HIV. The epidemic and historically familiar nature of TB causes a misrecognition and thereby delayed (or absent) diagnosis of many cancers. Yet the presence of an oncologist who does fine needle aspirations facilitates the diagnosis of extra-pulmonary TB. The public health apparatus and resources brought by one epidemic (HIV) facilitate and force the recognition of the other two epidemics. However, the configuration of the health service makes co-morbidity difficult to manage – and parses infections by citizenship. Non-citizens are covered by the national programme for TB, but unlike Batswana they are not otherwise covered under the system of universal care and so they must pay for antiretroviral drugs (ARVs) and oncology out of pocket. In order to understand the syndemic roots of the situation (Singer 2009; Meinert and Whyte, this volume), let me step back and explain how this problem has unfolded over time in the briefest of terms. What we will see is a field of synergistic complexity and widespread distress similar to the case described by Meinert and Whyte (this volume) in Uganda, in which caregiving resources are overstretched, existential angst is widespread, and no one therapeutic domain is sufficient to apprehend, much less tend to, the syndemic field.

## Tuberculosis: The colonial epidemic

Tuberculosis was the great scourge of Southern Africa, including Botswana (previously Bechuanaland) for much of the twentieth century. European observers in the nineteenth century had remarked on the seeming absence of consumption/phthisis in the region, but this would soon

change. In the late nineteenth century, the British colonised Bechuanaland and eventually ran the country as a migrant labour reserve for the South African mining industry, a labour regime structured by the institutionalised racism that would reach its fullest expression under apartheid. As historian Randall Packard has described, in the late nineteenth and early twentieth centuries the mines became an engine for the introduction and then dissemination of TB, which reached epidemic proportions in places like Bechuanaland by the 1930s (Packard 1989).

Tuberculosis remained endemic at very high rates even after Botswana gained its independence in 1966. The new nation inherited a handful of mission hospitals and clinics, but essentially had to build a health system from the ground up. By the 1970s and 1980s, a now independent Botswana had developed enough reach in its new primary care system to begin expanding access to antibiotics for TB patients. In 1975 they launched the National Tuberculosis Control Programme, introducing short-course chemotherapy in 1986, which was already making significant progress when they began implementing the directly observed treatment, short course (DOTS) therapy in 1993. The annual risk of infection declined from 5.8 per cent in 1956 to 0.1 per cent in 1989 (Republic of Botswana Ministry of Health 2007, 11). Tuberculosis notification rates declined from 506/100,000 in 1975 to less than half that figure by the end of the 1980s. Undoubtedly, this decline in TB rates was also facilitated by rising incomes and expanding social welfare programmes which together meant a rise in general nutrition. Unfortunately, this decline in TB was short lived. As outlined above, TB rates soon began to rise again in the face of widespread HIV infection, but the point here is that TB policy was foundational to the public health system in the country.

As I have described elsewhere, the history of TB was a fraught one in Botswana. Fuelled by, and mapping onto, a migrant labour economy that separated husbands and wives, parents and their grown sons, the TB epidemic shaped a moral imagination that scrutinised and pathologised women's sexual and maternal behaviour. Improper sexuality (often an issue of timing and purification) was understood to produce illness in children and partners, even as the migrant labour economy exposed women to overwhelming caregiving burdens and extreme economic vulnerability. The symptoms of pulmonary TB overlapped with those of a Tswana disease *thibamo* that resulted from the violation of sexual and parenting expectations (in terms of timing of liaisons, modes of purification, etc.) and thereby carried some moral tinge.

Meanwhile, throughout the colonial and post-colonial period, the biomedical establishment focused on *pulmonary* TB when designing

diagnostic, preventive, epidemiological and therapeutic interventions (Livingston 2005). Yet in the mid-1950s, extra-pulmonary TB accounted for fully a third of registered cases of TB. Extra-pulmonary TB has continued to account for a significant portion of the known burden of TB infection in Botswana, despite an epidemiological system premised on sputum smears and x-ray technology that is designed to identify and count pulmonary cases.

## HIV/AIDS: The epidemic of national existential emergency

The HIV/AIDS epidemic in Southern Africa was seeded through the high mobility and economic inequality of the population which began under the colonial migrant labour system. It built upon its legacy of sexual suspicion and overwhelmed caregiving networks. Like the TB epidemic that preceded it, HIV/AIDS too hit people in their prime. Young children, young adults, and the middle-aged formed the bulk of the patient population. Despite preventive efforts by the Botswana Ministry of Health, by the mid-1990s, the epidemiological scale of the HIV/AIDS epidemic had overwhelmed the health service which was designed to prioritise primary care. Hospitals, clinics, and private homes buckled under the weight of long-term, terminal illness. HIV brought TB back with a vengeance. Within a few years of the declared success of the national TB programme, the disease was palpably present and its prevalence escalated at an alarming rate. Meanwhile, the scope and scale of illness and death presented a grave moral crisis within the country and an existential crisis for the nation itself.

In 2002, when Botswana began its national antiretroviral programme, TB had already resurged and gained visibility as an epidemic of co-infection. Batswana to some extent made sense of HIV/AIDS through older understandings of existential crisis, epidemic, latent infection, and toxic sexuality through their historical experience with pulmonary TB/*thibamo*. These ideas were further fed by public health messages about sexual dangers and dirty blood. The incredibly high death rates amplified and added new vital dimensions to the problems of social toxicity associated with the disease as families and communities struggled to make sense of and cope with the impossibly high volume of death and caregiving needs in their midst.

The Botswana government, reeling from the scale of the HIV/AIDS epidemic, publicly feared the long-term viability of the nation (Mogae 2001). By the mid-1990s, the government had already begun to parlay this epidemiological crisis into new transnational research partnerships and investments, successfully marketing themselves as a clinical research and training hub. Over time, the government would expand these partnerships significantly, first around TB and then HIV/AIDS and then eventually cancer.

The new ARV programme, at once a political and a public health innovation, introduced the question of citizenship directly into the heart of Botswana's public health system. It did so just at a moment when high numbers of undocumented immigrants were arriving in Botswana fleeing economic and political collapse in neighbouring Zimbabwe. Whereas TB treatment had long been extended to immigrants in accordance with WHO recommendations, access to free care in the new ARV programme (like other medical services in the country) was limited to those who could provide proof of citizenship. Over time, experience with the ARV programme, like the TB programme a generation earlier, began to produce a cautious, and no doubt fragile therapeutic optimism among many patients and relatives, and an attendant politics around expanded access to biomedical technologies.

## Cancer: The emerging epidemic

While there were well-documented cases of cancer in Bechuanaland/Botswana going back to the mid-century, the disease was not well accommodated by the public medical system until the cancer ward in Princess Marina Hospital (PMH) was opened in late 2001. Before this, patients with diagnosed cancers were either sent to Zimbabwe (previously a site of high quality medicine) or South Africa for oncology treatment, and/or sent home to be tended by family until death. However, in the face of the escalating HIV/AIDS epidemic, and the new ARV programme, and with cervical cancer gaining increased international attention, Botswana developed a new oncology service in PMH (Livingston 2012). This was quickly expanded through a domestic public–private partnership with the Gaborone Private Hospital, which the Ministry of Health supported in their bid to acquire and run the national radiotherapy service. Eventually, access to clinical oncology was expanded to the north of the country

as well. An oncologist from China was brought, through a bilateral agreement, to work in the medical ward of Botswana's second referral hospital, which served that region.

The development of an oncology service enhanced diagnostic capacity for cancers in the country. Not only were the expected cancers among patients with HIV now emerging in growing numbers, but also a significant HIV negative patient population began arriving at the PMH oncology ward, and soon the service was overwhelmed by patient volume. In recent years, efforts have begun to train doctors in the primary and provincial hospitals to diagnose and treat routine cases of KS, and efforts are underway to diagnose and treat cervical cancers early through new see-and-treat technology beyond the two referral hospitals. However, for the most part, cancer diagnosis remains highly centralised and the pace, volume, and quality of cancer diagnoses (which in turn feeds into epidemiological knowledge) is constrained by the limits of laboratory, surgical, and imaging capacity in the country.

The combination of a centralised and over-stretched diagnostic capacity, the lack of screening services (except for new cervical cancer screening programmes for HIV positive women), bottle-necks in the referral system, the novelty of the disease category in the country, and the problem of co-infection with HIV, which both makes cancers more aggressive and also limits treatment options, means that the majority of cancers are diagnosed at an already late stage (stage 3 or 4), and mortality rates are high.

It is now possible to see that the epidemic of HIV clarifies the presence of the co-morbidity. HIV makes cancer visible – institutionally and epidemiologically. It has also made TB visible again after a period of dormancy. Meanwhile, the presence of an oncologist/cytologist in the hospital who performs fine needle aspirations on swollen lymph nodes helps to diagnose extra-pulmonary TB, thereby making it more visible. Yet at the same time, the epidemic of TB often delays or confounds the diagnosing of cancer, since most clinical staff have rightly learned to suspect TB when faced with persistent cough and wasting, or swollen lymph nodes. There are three vertical programmes in the health system one for each of these diseases, even as each programme acknowledges and attempts to grapple with the problem of co-infection.

## Receiving a differential diagnosis

Within the oncology clinic, historical experiences begin to layer onto one another. Though there have long been cancers in Botswana, the novelty

of oncology combined with the rapidly emerging epidemic scale of morbidity make the disease category a protean one in the popular imagination. Patients make sense of their cancer through historical experiences of TB and HIV/AIDS. In 2006, 2007 and 2008, this meant that TB was known, shameful and feared, while cancer was neutral. It also meant that relatives often assumed cancer patients really had HIV, when they might actually not, and it meant that patients with HIV who were now receiving a cancer diagnosis at first might not understand that this was an entirely separate disease with which they were now additionally faced. These ideas were further confused by the regular blood counts that were taken for cancer patients, since neutropenia meant that a scheduled dose of chemotherapy would have to be delayed. Such routinised tests and the continual talk of the strength of the patient's blood, made cancer resonate with clinical practice and communication around HIV. Key symptoms – lumps, wasting, coughing and dyspnea – meanwhile, also resonated with TB.

Over time, cancer is gradually becoming more familiar in popular experience, so these dynamics are in flux. However, here is how they appeared in my field notes from the oncology clinic in 2007 and 2008.

> A young woman with enlarged lymph nodes comes for a second fine needle aspiration. Before beginning the procedure, Dr P thinks it looks like TB and tells her this. She gets very upset and begins to cry. She has had a fever for a few days now. Dr P reassures her, 'TB is *good* it can be treated. It is better then *kankere* (cancer). In 6 months you are cured.' Perhaps the fever is part of what is making her so emotional.
>
> A young guy comes in to collect the results of his fine needle aspiration. He speaks excellent English (suggesting his level of education). He lives in a neighbourhood of Gaborone. The test was done in the parotid area. It turns out he has TB and so he is told he should also get tested for HIV. He looks so upset – quiet but upset. We try to explain to him that this is good news. 'You do *not* have cancer,' but he doesn't seem to believe us that this is a positive thing. The 47-year-old woman who looks miraculously young and wore that beautiful *tukwi* (headscarf) and black and white shirt finally comes back to gets her results from the fine needle aspiration (the original slide was lost by the medical ward). She has TB and looks a bit upset especially for someone who was so calm through

everything. Again I am struck by this incredible contrast between the cancer diagnosis and the TB diagnosis in popular reactions.

A young guy 33 years old comes with KS in his lungs, hand, groin, mouth, tongue, and palate. He has HIV.
Dr P asks 'Do you know what your problem is?'
'*Yes'* he says, 'I know what my problem is.'
Clearly, he is already tired of all the questions and the counselling (the IDCC clinics and HIV testing and treatment use a didactic counselling script in which the patient learns to repeat their status, CD4 count, etc.) (Brada 2013).
'I am HIV positive.'
'No. Do you know why you are *here?'* (Meaning the oncology ward.)
'*Yes.* It is on the card.'
The nurse pursues further. 'No. Not what's on the card. Do you know what is this place?'
'They told me that side – at the clinic.'
'What?'
'They just used some big words. I don't know.'
'You have skin cancer (*kankere ya letlhalo*) or KS. This problem is also in your lungs and in your mouth.'
He says, 'Doctor, I am suffering. I walk 50 metres and it feels bad like I ran 100 metres.'
'We know.' I finally interject and also try to explain. '*Wena, nyaa* – you have two problems, *di le pedi*. These problems are friends. *Kankere* and *mogare* (HIV) are different, but they can go together.'
He looks like he doesn't want to know this.

A man in his 30s, well dressed but imperfect English. His KS is mild, but it is how he is learning that he has *mogare*. I think he is stunned – quiet, but stunned.

The woman from Phakalane with the one big KS lesion on her heel is back a week early. She and Dr P have a debate as to whether it is better or not. It is half the size it was before but now it is infected so she has a lot of pain in her ankle. This is because of the infection not the KS so they disagree. To Dr P, the pain is from the cellulitis but the KS is better. To the patient it hurts more so clearly she is worse. The nurse (Christine) struggles to explain that there is *kankere* (cancer) and *mogare* (HIV – the virus) and *megare* (bacteria/germs/virus). I pitch in, and so does the student nurse.

A woman comes to get her results. She is in her mid-20s, on HAART and has been taking the TB prevention programme (IPT) for 6

months. Her fine needle aspiration shows she has TB. When told this she starts to cry, and she really cries for a few minutes. Dr P tries to console her. 'No, this is not a big *mathata*. You will be fine.' But she leaves in tears.

There is a man in Male A bed 2 with Hodgkin's who is HIV negative, but emaciated. He wants to be checked for TB. Dr P says he is smart. We should not be fooled into assuming we know why he's so thin, even though Hodgkin's is a wasting disease.

Patients stood in a thicket of cross-referencing between the three diseases as they attempted to understand their situation and navigate treatment. Making sense of cancer meant separating it from TB and HIV, but it also meant putting them back together. Yet such ontological exercises were necessary in order to navigate the treatment landscape. One could not 'default' on chemo or antibiotics just because they were diligent about their antiretrovirals, at least not without serious consequences.

From the perspective of the oncology ward a simple TB diagnosis was terrific news. For many patients, it was the opposite. At that point, cancer was still relatively unknown to them, while TB had long been feared and was perhaps shameful. Furthermore, TB was often the vehicle by which someone learned that they had HIV, which carried its own burden of fear and perhaps stigma. However, as they developed experience as a cancer patient, they came to realise how awful it was, with some patients remarking to me that even HIV was much better than cancer.

Within the hospital, differential diagnosis had other effects. Whenever bed space was available a cancer patient would be housed in the cancer ward. Though the oncology ward was greatly overworked, it was quieter, less chaotic, and more orderly than the medical wards where most TB and/or AIDS patients would be. In the medical wards, many patients were on gurneys packed into hallways or on mattresses crammed into empty spaces on the floor. In the cancer ward, space was tight, but the oncologist simply did not allow floor beds. Patient-to-nurse ratios were smaller in the cancer ward, and staff became familiar with patients and their relatives over the cyclical process of their care. Furthermore, pain medicine was more readily dispensed and fewer people got lost in the shuffle. More than once I remember the medical officer, faced with a patient co-infected with cancer and AIDS, who lay dying in the medical ward, deciding to transfer this patient to oncology, calling her 'our patient'. This transfer was meaningful, intended as a final gift to her and her family, allowing her to die from cancer and not from AIDS.

Meanwhile, different drug regimes seemed to create an overlapping intelligibility but in fact were often misleading in their cross-references. Second line cancer treatment is less efficacious than first line, in contrast to second line antibiotics. Prophylactic isoniazid as a public health programme to some extent mirrors the logic of the new prophylactic antiretroviral programme (PrEP), while chemotherapy drugs, by contrast, have lifetime limits. The nausea that often accompanies ARVs tends to fade for patients over time, while the nausea that results from chemotherapy tends to escalate with each new cycle.

> Mma T, a nurse counsels a patient with KS – a young woman. She tells her, 'This medicine will make you nauseous, you will lose your hair, but this is temporary.' The patient is visibly upset about this, but Mma T says, 'Look with TB you take a pill a pill a pill. With *kankere,* the drug is *so* strong you take an injection every few weeks instead.'

The same extrapolating logic can also go in reverse.

> In the oncology clinic G, the young woman with Hodgkin's is still here. She is in remission but coughing – is it TB? She and I go together to see if we can find Michelle to do a sputum smear, and on the way it is clear she knows less than we think. Dr P said to her earlier, 'I think you have TB my friend' and when the nurse starts to translate he says, 'No she speaks English!' I explain to her about what TB is and what it would mean for treatment. It turns out she is worried that it would be like cancer medicine but every day for months. I say, 'No. It is much easier – the pills, it is just that it lasts for months, but there should be fewer side effects.'

## Clinical intelligibility

In this context of rampant co-infection, differential diagnosis and the charting of a clinical strategy were blurrier than the moments of clinical communication presented above would suggest. An enlarged lymph node could contain both lymphoma cells and tubercle bacilli. Lungs could be plagued with both TB and lung cancer or TB and KS. The unevenness of the technological infrastructure further contributed to the diagnostic and treatment challenges. Even if there was only one disease present, it

could be hard to come to a definitive diagnosis (Vento and Lanzafame 2011). Without the normative body available, and faced with an unstable technological field, the oncologist and other doctors were often left working empirically.

Consider, for example, this scene in the cytology lab from my field notes in June 2008.

> Dr P, Dr S, and I are in the lab using the teaching microscope to try to make sense of what is happening to a middle-aged woman with Burkitt's lymphoma who has just had a spinal tap. Dr P explains the problem. 'Here you spin, then take the upper part off and put the bottom part in. But here, there is no cytology centrifuge, which would spin directly onto the slides and this is part of why the slides are destroyed. You can see that there are lots of cells here, which does suggest central nervous system involvement of her lymphoma but the cytoplasm is destroyed in those cells.' We search the two slides for intact cells. Dr P says if we can find a single blast, then we would know. But it is not possible. But there is no bleeding evidence and ordinarily one would expect to see between 4 and 12 cells. Here there are at least 100 so this really looks like the lymphoma is there. Why else? It could be TB or cryptococcal. We will have to wait for the national TB lab on that. But Dr P doesn't think the TB lab can definitely see it.

Or this scene from a morning meeting in the medical ward in 2007.

> The medical officer presents the case of another patient where they are querying lung cancer. His x-ray is displayed. Is it a chronic pulmonary disease like pneumoconiosis or is it a cancer of the lung? Or is it chronic TB? The American medical student and the visiting professor pitch in to push towards cancer. The head of department says first we need to rule out TB. The patient has a history of 24 years in the mines. They agree that they need to rule out TB first, but the x-ray does not provide a clear diagnosis.

Or this one from the oncology ward in 2007.

> We are on the Monday ward round. The woman with KS who we brought as a cancer patient to be transferred from the Female Medical Ward is having problems breathing. She had a pleural

effusion tapped over the weekend. It was blood tainted, and therefore suggestive of KS. But now she is still having trouble breathing. Now the question is – is this TB or does she need her lungs irradiated. Dr P decides to go for 2 more weeks on TB treatment and see if she responds. If not, then irradiation.

Problems of technical capacity within the system hamper the outcome of public health programmes that are designed to target co-infection. The Isoniazid Prophylactic Therapy (IPT) programme for HIV positive patients began in Botswana in 2001. In a logic that foreshadowed the PrEP programmes for HIV, IPT required screening for active TB among all persons diagnosed with HIV infection, and those not requiring treatment for active disease, receive 6 months of prophylaxis. The IPT programme, therefore, is premised on being able to screen out active disease. However, as we have seen, some patients were on IPT for months before their TB was diagnosed, and some clinicians suspected that this must contribute to a rise of MDRTB.

## Living and dying with co-infection

If co-infection presents challenges to clinical staff and to institutional efforts, for patients, and the relatives who help care for them, existing in a state of unfolding and acute medical complexity is profoundly trying. Physically, any one of these diseases can be miserable and disorientating, much less two or three at once. The same can be said of the pressures of overlapping and intersecting diagnostic and treatment regimes. The bureaucratic and institutional challenges of co-infection mean that patients have multiple appointments and advice to manage, which are incredibly time consuming between long queues at pharmacy lines, on waiting benches for imaging studies or blood taking, for clinic appointments, at bus and taxi ranks, not to mention the expense of travel. Furthermore, it was also existentially overwhelming for people to learn they had all of these problems at once. If there are social models and messages out there for how to 'live positively' with HIV or how to be a 'cancer survivor' there was precious little guidance for those trying to buoy themselves against the bodily insults and psychic uncertainties of co-infection.

Sometimes, this means that a patient with HIV refuses a pap smear, recognising that she is not ready to take on cancer as well if it were to come back positive. Sometimes, it means that a patient fails to come and collect the results from their fine needle aspiration until after some months, when the symptoms of their cancer become so overwhelming

that they are now desperate for relief. Sometimes, patients who were co-infected looked at me wistfully and remarked that they wished they just had AIDS, which now seemed so simple and relatively manageable rather than both AIDS and cancer. In late 2006, I visited a young woman in her village home. She had already completed treatment for KS, which had destroyed her knee and she remarked, '… I know if it were the HIV alone, I could take the ARVs, stand up and go and work. But now this cancer has actually crippled me. I can't walk, I can't work.'

Imagine what it feels like to be the parents of this young man.

> The parents and aunt (*mmangwane*) of the 29-year-old man with penile cancer and KS, TB and HIV come to talk. They have been waiting since noon and it is now 5.00 p.m. (This is because Dr P first sees all of the patients and then only counsels relatives once all the chemo had been administered and the clinic visits completed). Dr P opens by telling them that the situation is hopeless. 'Your son has two cancers, HIV and TB. It is too much.' They have no questions, though the father is a military officer and speaks excellent English. The father says, 'All we can do is hope. It is in God's hands now.'

Imagine still what it feels like to be this patient with half a penis, tethered to an oxygen tank, gasping for breath, in tremendous pain and misery. Then again, imagine how relief slowly came to him as against all odds, he recovered from this crisis to become just an HIV patient again (albeit one with scarred lungs and half a penis).

Think about what Agnes has been through. Born in the late 1930s, she was still a farmer when I met her in 2007 in Gaborone where she had been sent for radiotherapy. She was living with her daughter, one of six children she had, though two had already predeceased her. The same year she lost her son, 2004, was the year her problems started. She was ill and went to the clinic in her village where they diagnosed her with TB. In 2005, she had finished the TB treatment and started on ARVs. Her chest was better, but she developed swollen glands and there was no improvement despite all the pills she was taking. She kept going to the clinic complaining of the swelling, and then finally in February 2007 they sent her to Nyangabwe. There they took a specimen and sent it to the laboratory and diagnosed her with cancer. The doctors at Nyangabwe told her that because of her age and her immune status they could not operate on her to remove the tumour (which I presume was in her hypopharynx but since the doctors did not tell her what type of cancer she had, I could not clarify this in my conversation with her). When I met her she was just beginning radiation treatment.

Co-infection asks a tremendous amount from patients and from relatives. It leaves them destabilised, without a clear centre of gravity around which to organise their energies and their futures. It exhausts them in ways both large and small. This very exhaustion underscores a palpable truth about the body in sickness, one that is effaced in the intellectual work of statistical categories and biomedical specialisation.

## Provisional conclusions

How should we make sense of such complexity on an epidemic scale? What does biological complexity do to the logic of biodeterminism and any assumed separation between biological and social life? Will new categories emerge to capture co-infection, such that cervical cancer with HIV is a different disease than cervical cancer without? Or will we see at least a minor retreat from disease specificity? Or an expansion of local biology into the foundational logic of biomedicine as new work in epigenetics and the microbiome suggest (Lock, this volume)?

Co-infection and co-morbidity in the biomedical institution was not the same as a more holistic framework of misfortune with ramifying symptom constellations mapped onto broader social grids, such as Tswana disease nosology might afford. Yet for cancer patients, their relatives and their clinicians, addressing cancer meant separating it from TB and HIV even as they mingled in the body and the social field. Why stop with these three diseases? I could easily make a case of hypertension and diabetes as part of this complex co-morbid landscape.

What about the structure of the health system itself and the need for medical and epidemiological knowledge to emerge at the intersections between diseases? The epidemic scale of co-infection in a context of uneven technical infrastructure presents clinical challenges and raises questions that contribute to the ambiguity of oncological practice in Botswana. The Botswana Ministry of Health is aware of the problem of co-infection and is trying to accommodate it within a health system that has evolved through consecutive and aggregating waves of epidemic. However, this remains difficult to coordinate and systematise within a single hospital, much less a health system.

Experiences of co-morbidity in Botswana point to scalar problems of public health and institutional policies that are designed vertically around an implied presumption of disease specificity. A close look at co-morbidity reminds us that epidemiological patterns layer on top of one another over time, as one disease gains traction via another. At the same

time, it reveals the problem of living co-morbid. Bodily insults cluster together in experiences that defy the disease-specific logic of clinicians and medical institutions, as well as the master narratives and metaphors of disease-specific biosociality.

## Notes

1. Pursuing diabetes (or hypertension) is beyond the scope of this essay, which already feels unwieldy. But it raises all sorts of questions about TB and HIV co-infection in Botswana.
2. A colleague tells me that the Ministry of Health has asked that he begin to collect TB data in his prospective cohort study of cancer. He notes that it will be challenging to get accurate data because many patients receive TB treatment before their eventual diagnosis of cancer (lymphoma, lung cancer, etc.), so it is difficult to know whether the TB was originally misdiagnosed or if they really have concurrent TB and cancer (Scott Dryden-Peterson, personal communication).
3. 'Results: Between 2003 and 2008, prevalence of untreated AIDS (CD4 ≤ 200 cells/μL) fell from 5,510 to 1,170 per 100,000 ($p = 0.001$) and median CD4 at ART initiation increased from 106 to 160 cells/μL ($p = 0.002$). During this period 8,494 cancers were diagnosed. There were no significant changes in incidence of AIDS-defining (41.1 per 100,000, $p = 1.0$) or non-AIDS-defining (73.1 per 100,000, $p = 0.57$) cancers. However, incidence of KS declined by 4.83% per year, $p = 0.017$. Incidence of non-Hodgkin's lymphoma (NHL) and head and neck squamous cell carcinoma increased 12.0% ($p = 0.007$) and 10.8% ($p = 0.019$) per year respectively. Taken together, possible human papillomavirus (HPV)-related tumours increased 6.0% per year, $p = 0.006$.' (Dryden-Peterson et al. 2012).

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# Chapter 8
# Legacies of Violence: The Communicability of Spirits and Trauma in Northern Uganda

Lotte Meinert and Susan Reynolds Whyte

How may the spread of the biomedical concept 'trauma' as well as *cen* spirits in Northern Uganda be understood as part of syndemic processes of situated concerned responses to violence?

Sitting on the floor in her kitchen hut, Wilma recounts the story of her brother's son, Oloya. Like so many other children in Acholiland, he was abducted by the Lord's Resistance Army (LRA). When everyone else was interned in camps for Internally Displaced People, Oloya was in the bush with the LRA. From the age of 12, and for 7 years, he was with the rebels, who forced him to kill and to step on dead bodies. When he finally came back, he was taken to the reception centre for returnees run by World Vision in Gulu town. After a year there, he really came home, that is, back to his paternal family in the village, where he stayed with his father's mother. 'It was then that the *cen* started disturbing him,' says Wilma. He used to dream that someone was on his neck wanting to kill him and in desperation he would run outside, pursued by his worried home people. His family took him back to World Vision, who brought him to Gulu Regional Referral Hospital. The doctors there recognised his problem as trauma. Many who have been in the bush suffer that way, they explained. Most with such a history saw killing or killed people themselves. They have flashbacks – they cannot forget. Take him back to World Vision, the health workers advised. However, Oloya's stepmother, who was an *ajwaka*, a diviner/healer, was with him that day and she had another plan.

'Let me have my son and I work on him,' she said. As she shells her groundnuts, Wilma tells about the methods they used for sending the *cen* away. She was there and saw how they called the *cen* to speak.

It accused Oloya. 'You walked on me!' He replied, 'I didn't mean to do it, they forced me.' Pulling a black goat, the group of relatives went to the bush and made Oloya remove his shirt and crawl into an anthill. Well-bitten, he withdrew, and they slaughtered and roasted the goat. Then they took pieces of meat and threw them in each of the four directions, saying, 'You leave our son. He didn't mean to do it, he was forced.' They put medicine (*te ocuga*) in his nose. After that he went to stay with his cousin (his father's brother's son) in Gulu town. There was some improvement but still Oloya had disturbing symptoms including bad headaches. What to do? The cousin with whom he stayed took him back to the hospital; he did not believe in *cen*, although his own mother was an *ajwaka*. Oloya's stepmother was convinced that the *cen* wanted him to be an *ajwaka* like herself. They scheduled a day to do the initiation ceremony, but when the day came, Oloya never showed up. He did not want to be an *ajwaka*. He stays in town, working as a mobile telephone agent. Up to now, he takes two kinds of medicine: tablets from the hospital and the *te ocuga* herbal medicine recommended by the *ajwaka*.

## Studying legacies of violence

Oloya's story may serve to highlight a methodological and a conceptual matter in the discussion of how legacies of violence are spreading in the contemporary world. The methodological matter is one of scale. For our purposes here, we will distinguish three dimensions: the family, the individual, and the broader regional and international configurations of scale. Our concern is especially with the family; as Oloya's story suggests, dealing with the everyday legacies of violence is a family affair. However, in order to understand the possibilities that families have, we must recognise other scales as well. This is particularly the case given the conceptual matter of biosocial complexity that this volume addresses. Biomedical ideas and treatment practices spread through global connections and regional interventions. They are tried out on individual bodies shaped within local biologies.

Like other scholars, we are intrigued by the possibility that trauma, and post-traumatic stress disorder (PTSD) in particular, are 'communicable' conditions, spreading to more and more people around the globe. We agree that the transmission of trauma must be understood in terms

of transformations in sensibilities and interventions emanating from the Global North (Fassin and Rechtman 2009) and the appropriation of these within local political and cosmological worlds (Bubandt 2008). In the case of Northern Uganda, these local worlds include *cen*, the spirits of the resentful dead, which also seem to be increasing as a legacy of violence. The co-existence of trauma and *cen* must be considered on a family scale in relation to the concerns and possibilities of people like Wilma and her nephew Oloya. For families struggling to deal with the legacies of violence, trauma and *cen* are repertoires (ways of talking and performing) that constitute plans for action and possible relief of affliction. The failures of one kind of treatment help to grow interest in the other.

The suffering and caregiving related to trauma and *cen* are examples of local biology (Lock and Nguyen 2010) that require a biosocial framework to interpret the illness experience and evaluate the outcome (Kleinman 2015, xv). In our exploration of trauma, we examine the legacies of mass violence for individuals, families and the social worlds in which they live and try to recover (Hinton and Hinton 2015, 1). Persons (mindful bodies) like Oloya have been formed by the present and past circumstances in which they live and they and their families experience and manage affliction accordingly.

Starting from the situated concerns of persons and families confronted with recalcitrant problems, we suggest that trauma and *cen* may be contested, accepted, or simply ignored as a possible way of dealing with mindful 'dis-ease' (Scheper-Hughes and Lock 1987) in post-conflict situations. Family concerns are almost always in the plural. That means considering the range of problems that either *cen* or trauma might address. As we will show, the behavioural symptoms of both *cen* and trauma often co-exist with what biomedicine might diagnose as alcoholism, HIV and diverse health conditions. In biomedical discourse, this is commonly described as 'co-morbidity', a clinical term used for biological conditions (see Livingston, this volume). In a broader perspective, medical and other problems thrive in particular social, economic and historical circumstances. We suggest that the rapid spread of multiple interrelated problems be seen as syndemic (Singer and Clair 2003; Singer 2009) rather than as instances of co-morbidity or co-existing epidemics. As repertoires, trauma and *cen* are appropriated where other problems (drunkenness, domestic violence and land conflicts as well as disease) are spreading in the 'conducive' environment of war, displacement and poverty.

In Northern Uganda, the Acholi sub-region has been worst hit by the long running civil war. The LRA, led by Joseph Kony, and consisting

mainly of Acholi people, fought most intensely and persistently in the Acholi districts. The national army, the Uganda People's Defence Force, interned practically the entire population, about 1.8 million people, in crowded camps, which they called 'protected villages', for up to 10 years. Yet the army was not able to keep the internees safe from abduction and killing by the LRA, and the national soldiers themselves committed atrocities against those they were supposed to guard (Dolan 2009). Finally, in 2006, a Cessation of Hostilities Agreement was signed in Juba, and people gradually began to return to their rural homes. When we first began collaboration with Gulu University in 2008, many people still remained in the camps. Awach sub-county, where we have worked most consistently, was no exception. Over the years, we have followed the resettlement process (S. Whyte et al. 2013), including the return of dead family members buried in the camps, who are being exhumed and reburied in their rural homes (Meinert and Whyte 2013).

In the course of our work, we talked with many families affected by *cen*, and we became acquainted with NGOs and visited health facilities offering treatment for trauma (Whyte et al. 2015). We interviewed *ajwaki* dealing with *cen*, and Christian clergy who counselled and prayed for victims of *cen*. In August 2014, we more systematically added to our understanding of these matters by interviewing 19 individuals or families who claimed to be affected by *cen*, revisiting two health facilities where trauma was treated, and having long conversations with an *ajwaka* and with a psychologist at an NGO specialising in the treatment of PTSD.

In considering the communicability of trauma and *cen*, we ask several questions. How and by whom are they transmitted? What is communicated? How are these ideas appropriated and used by those who are communicating? Moreover, what are the conditions of communicability?

## *Cen*: The ghosts of the resentful dead

Spectres of violence that visit and haunt the living in dreams and in waking states are known in many places. In Vietnam (Kwon 2015) and Indonesia (Good 2015), the spirits of the dead become more prominent in the public imaginary after periods of mass violence and destruction. However, this phenomenon always has particular local characteristics. Acholi people explain that *cen* are the spirits of people who died violently or unjustly, and for whose death no compensation was made. Those whose corpses were not buried properly may also, as *cen*, affect others who come upon their remains. *Cen* are a legacy of violence in that they result from

the malicious destruction of human life and the imagined resentment of those who died with a legitimate grievance. Thus, the idea of *cen* is fundamentally a moral one. It attributes to the dead a sense of righteous ill feeling that may cause misfortune to the living.

The word '*cen*' with the same general meaning is widespread in Eastern Africa. It is found in all the Nilotic languages (Evans-Pritchard 1956, 173) and in a Bantu form (*omushieno*) among neighbouring peoples (Whyte 1997, 132–40). Long ago, Evans-Pritchard explicated the moral nature of ghostly vengeance (*cien*) among the Nuer, people closely related to the Acholi. 'The essence of the concept is the notion of a wrong unrighted, of a grievance which demands, and rightly demands, redress' (Evans-Pritchard 1956, 176). As a plan of action, the idea of *cen* thus suggests attempts to right wrongs or at least to mollify the resentful spirit.

If someone causes the death of another, even if indirectly, reparation should be made to the family of the deceased. Failure to do so may be cited as the reason for *cen* to afflict the wrongdoer or his (rarely her) family. In principle, clan members of the offender should come together to pay compensation. We found several cases where this had been enjoined but never followed up. If it is not possible to identify the family entitled to compensation, then something should be given to the *cen* itself. This usually entails sacrificing an animal, as in Oloya's case, after the *cen* speaks through its victim to assert its demands. Or, as some put it, the *cen* wants blood. Some *cen* insist that they will only be placated if the person afflicted becomes an *ajwaka*.

As repertoire, *cen* is a collection of possibilities alluding to a fundamental assumption about the morality of actions and the powers of the wronged dead. *Cen* spirits are often referred to as evil because they inflict suffering on the living. They are contrasted with *tipu*, the spirits of the dead who are neutral or beneficial towards their descendants. However, the dead become *cen* because they were offended in some way, so recognition of *cen* acknowledges wrongs committed by someone sometime even if no one now remembers what that wrong might have been.

The signs and symptoms of *cen* cover a wide range of strange and disturbing behaviour. It was often family members who recounted the distressing developments that led them to consider *cen*. Irene started to tell her own story, about how she went out to relieve herself one night and the darkness became darker, then changed to red like blood. Soon her husband took over to recount what she could not remember, that she ran off, refused to talk when they found her and would not eat or drink. At night, she still cries and struggles in her dreams and in the morning recalls a huge man with bulging eyes threatening to kill her with a spear

or water flooding on the road and then turning red. She herself says that she feels like some living thing is walking in her brain. It makes her dull and forgetful. 'I live in the hand of God,' Irene added.

A man told how his wife Anna refuses to eat or light a fire to cook for her children or work in her garden. She has headaches and hears a voice that is sometimes a man's and sometimes a woman's. We visited her, looking painfully thin and withdrawn, where she was staying at her brother's place. When she said she wanted to go back to her own home, her husband remarked, 'That is not herself but the evil spirit speaking.' Others told of children falling in fits, with saliva drooling, or children who wandered about, laughed uncontrollably, burst into tears, fell silent, and had to be taken out of school because of their strange behaviour.

Hellen recounted that her husband, father of their 11 children, had been a successful businessman, but is now kept locked up lest he run off, become aggressive and get beaten up. Early one morning he suddenly woke and began to hit his children with a stick shouting to those who tried to intervene. 'Go away! Let me beat them, I want to kill them!' Although he spent a year in Butabika, the national mental hospital, is well cared for by his family, and is made to take tablets from the health centre every day, he has never become normal again.

How can we explain the spread of *cen*? The question is really a double one about both the transmission of affliction and the conditions in which the image of *cen* is communicated and flourishes. Those with whom we talked about how *cen* catches people mentioned several pathways of transmission. *Cen* can affect someone who comes upon a corpse and fails to acknowledge the wrong of its death and neglect. In line with the recognition that a moral offence has been committed, the passerby should say respectfully, 'I did not kill you' and 'I have buried you', placing a leaf (preferably from the *olwedo* plant) on the remains. Several accounts suggested that the afflicted person might have happened upon human remains without realising it, thus acquiring *cen* unknowingly. Or one can walk into a place where *cen* are hanging about, near the river or near a location where people were killed. Outbreaks of possession occurring in boarding schools have been attributed to proximity of killing sites. One can also be affected by *cen* because an ancestor killed someone and no compensation was ever made. The *cen* of the resentful victim may affect the descendants through several generations. So *cen* can be communicable within families. Finally, and importantly for our interest in trauma, *cen* may affect someone who has caused a death, committed a murder or seen a killing that was not acknowledged and compensated.[1]

Given these concerns about intentional and inadvertent killing, and the moral obligation to bury the dead respectfully, it is understandable that the wars in which Acholi people have been involved since the 1980s have provided fertile ground for the spread of *cen* affliction. In her major study of the Holy Spirit Movement, which preceded the LRA, Heike Behrend (1999) traces efforts to deal with the unreconciled spirits of those who died by violence. The Acholi soldiers who fought against Museveni's advancing army in 1985 and returned home after their defeat were thought contaminated by *cen* of those they had killed. Behrend argues that the problem was not so much that the returning soldiers had taken lives, but that they did not undergo rituals to cleanse them and appease the *cen*, as had fighters in earlier wars (Behrend 1999, 28). She suggests that they were unwilling to accept the authority of the elders in these ceremonial matters and also that warfare was anonymous so it was not easy to know whom one had killed. Many of these returning soldiers joined Alice Lakwena's Holy Spirit Movement, which invented new rituals to cleanse them of *cen* and carried out sacrifices to atone for the transgressions they had committed (Behrend 1999, 45). As Hutchinson described for the Nuer in the era of modern warfare, it was necessary to develop new ways of managing the increased numbers of unknown people killed in battle (Hutchinson 1996,107).[2]

*Cen* were thought to increase not only because of the rise in violent deaths, but also because the dead were not buried properly. When Acholi people were finally allowed by the army to leave the camps and return to their rural homes, they came upon human remains as they cleared the bush to begin farming again. If they did not actually see bones with fragments of clothing, they sometimes heard or saw or even smelled evidence of the neglected dead in the area.

Efforts to alleviate the effects of *cen* served to confirm its existence. There were at least three institutions that reinforced or even helped to spread the repertoire of *cen*. Most important were the *ajwaki*, the diviners and healers who identified *cen* and organised ceremonies to placate them. Several informants told us that the numbers of *ajwaki* have increased since the war. Reverend Abia was worried about the many women who had become *ajwaki* after leaving the camps. He thought that it was hard for people to start anew after so many years of internment, that women were oppressed and this work gave them respect and a source of income. The increase in *cen* because of the war went hand in hand with the increase in *ajwaki*.

Christian churches played an important role in dealing with *cen* as well. Many clerics and committed Christians acknowledged the existence

of *cen*. Reverend Abia and Reverend Onyango pointed out that the Bible itself tells of evil spirits. But for them *cen* pointed to the need for strong faith and prayer (and sometimes hospital medicine) rather than consultations with *ajwaki* and spilling animal blood in ceremonies. In several families (and even within the same individual), there were conflicts about Christian versus 'traditional' modes of dealing with *cen*, and they played out as a micro-politics of identity and influence. However, our point is that church recognition of *cen* served to confirm the idea and make it communicable within Christian discursive practice.

On a larger political scale, efforts were made to cleanse areas of *cen* as people moved back upon leaving the camps. These were organised by 'traditional' leaders, including the government-recognised *rwodi moo*. In an effort to acknowledge local concerns, the Northern Uganda Transitional Initiative (NUTI), funded by USAID, provided resources for sacrificial animals and other requirements so that ceremonies to send away *cen* could be performed. This was part of a larger tendency to recognise elements of Acholi culture that could be used in efforts to promote peace and reconciliation. The attention to *cen* and the need to cleanse areas and placate them was of scholarly as well as policy concern (Harlacher et al. 2006; Baines 2010; Finnegan 2010).

Two other reasons for the increase in *cen* relate to the nature of the problems with which they were associated and their resistance to available treatment. Most people said to be affected by *cen* had conditions that biomedicine would call mental or behavioural, though there were often grave somatic symptoms too. Thoughtful interlocutors pointed out that *cen* affects those who have other problems as well. Anna's husband noted that her *cen* affliction became much worse as the family got embroiled in a land conflict that involved violence and arson. In a study of former child soldiers, Akello and colleagues (Akello et al. 2006) suggested that *cen* especially affects children who are not accepted by their own kin and communities, when they return from fighting with the LRA. Problems of reintegration aggravate *cen*.

Many of those we spoke to told of efforts to seek biomedical treatment of their conditions. Like Oloya, people tried pharmaceutical remedies and in quite a few cases, they were still taking medications. Sometimes, their symptoms had diminished, but when they were not really cured, people continued to entertain ideas of *cen*. If the biomedical diagnosis was not accurate, if the pharmacotherapy was inappropriate, if people did not take their medicine properly, and if the problems went beyond what medicines could address, then biomedicine's shortcomings enhanced interest in *cen* as a possibility.

## Trauma and its treatment

During and after the war, trauma spread in Northern Uganda in several versions. One is the stringent monothetic category of PTSD, based on criteria in the Diagnostic and Statistical Manual (DSM) of the American Psychiatric Association (Young 1995, 118). PTSD is a diagnosis made by health professionals with training in psychiatry. It points toward psychotherapy and/or pharmacotherapy with treatment consisting of counselling and talking and/or medication with psychopharmaceuticals. In a somewhat looser version, trauma is understood as mental, emotional and behavioural consequences of personal experience of violence, needing some kind of care, counselling and monitoring. Finally, the English word 'trauma' has entered popular discourse in Acholi, especially among more educated people, to denote sadness and despair after loss or distressing events. It highlights the affected person's emotions and calls for sympathy. An example of this was when one of our field assistants told us about her elderly maternal aunt who had suffered trauma because she had lost all of her children to AIDS.

In all of its versions, trauma underlines the relationship between first-hand experience of violence or other wrenching events and the feelings of the person who has directly undergone them. Whereas *cen* can disturb the descendants of someone who violated or was violated, trauma affects the owner of the experience. Furthermore, where *cen* as a repertoire calls for exchange (that is, compensation to the wronged family or an offering to the *cen*), trauma calls for self-reflection, self-narration, and the treatment of the emotional and perhaps medicinal needs of the afflicted individual.

This kind of approach was already familiar in Uganda before the LRA war. The early response to the AIDS epidemic involved individual counselling, attention to feelings, and later on encouragement to take long-term medication, so many Ugandans were aware of these ways of dealing with chronic illness. The term 'counselling' and its various practices spread as government, donors and NGOs mobilised against HIV. AIDS counselling practices promoted historically specific Euro-American ideas of the psychological self (Rose 1998) and became known in Uganda by the early 1990s. By 2005, when antiretroviral therapy became widely accessible, counselling was closely associated with medicating the individual ailing body. The infrastructures of AIDS counselling and medication, which reached almost all corners of Uganda although unevenly, fertilised the ground for the spread of the idea that selves could be traumatised and healed through psychotherapy and pharmaceuticals.

Many international donors and NGOs were active in Northern Uganda during and after the war. In fact, it has been argued that their support made possible the military policy of camp internment (Dolan 2009; Branch 2011). The repertoires of trauma probably entered Northern Uganda through the NGO reception centres first established in Gulu in 1994. They received adult and child returnees 'from the bush', that is, those who escaped from the LRA, and offered a safe place to stay, medical care, assistance in tracing family members, some training, and support for 'reintegration'. A study in 2005 found that the most highly appreciated aspect of the centres was counselling. 'The word "trauma" is often used, and some ideas from psychotherapy inform efforts to help formerly abducted persons (FAPs) tell their stories, and even act out what has happened to them' (Allen and Schomerus 2006, vii).

Researchers documented the toll that the war and encampment was taking on the civilian population; a recurring theme was the high level of PTSD. One study in 2006 reported some of the highest ever rates of depression and PTSD in displaced populations, which were found among people in Gulu and Amuru districts, then still in the camps. Using the Hopkins Symptom Checklist-25 and the Harvard Trauma Questionnaire, 67 per cent met symptom criteria for depression and 54 per cent for PTSD (Roberts et al. 2008). Humanitarian organisations responded to the picture of mental distress by offering treatment for 'trauma', PTSD and depression. In 2012, a study identified 25 NGOs in the Acholi region providing treatment for trauma caused by the war (Whyte et al. 2015).

The modalities of mental health work varied. Some NGOs worked in collaboration with government health facilities at different levels. An important example is the Peter C. Alderman Foundation clinic within the Mental Health Unit of Gulu Regional Referral Hospital.[3] It is named after a young man killed in the attack on the twin towers in New York. His family established the foundation in part to deal with their own distress at his loss. The clinic specialises in PTSD. Patients coming for mental health treatment are referred for screening using an instrument based on the Harvard Trauma Questionnaire translated into Acholi. From its beginning in 2008 until late 2011, the clinic registered 850 patients. Records showed a strong pattern of co-morbidity. Most patients had more than one diagnosis (for example, PTSD and depression or alcoholism or psychosis or epilepsy) and nearly all received psychopharmaceutical medication in addition to counselling. One of the very few local psychiatrists bemoaned the fact that fluoxetine, a selective serotonin reuptake inhibitor that is standard treatment for PTSD, was

too expensive for general use in Uganda. Instead, the Regional Referral Hospital, like all government health units, relied on amitriptyline, an earlier generation of tricyclic antidepressant drug. Staff told us that even though the war had ended, new patients continued to appear because domestic violence and land conflicts 'triggered' PTSD. The Alderman clinic, like the Transcultural Psychosocial Organisation (TPO), another NGO, did outreaches to government rural health centres that lacked staff with training in psychiatry.

Other organisations provided care independently of public health facilities and eschewed the use of medicines. One of the most important was Vivo (victim's voice), a German-based NGO that provides treatment based on narrative exposure theory and started working in Northern Uganda in 2005. Psychologists, who had been treating asylum-seekers in Germany and displaced people in several countries, established an outreach programme, a clinic in Gulu town, and a programme to train lay counsellors. In partnership with other NGOs, they have screened several thousand people and provided treatment to about 1,000 who were considered to suffer PTSD. About 80 per cent of those they treat are formerly abducted persons. A counsellor meets with a client 10 times over a period of 5 weeks to help the client construct a lifeline and tell their life story, placing the traumatic events in the context of their lives and recounting what happened in great detail. Vivo Uganda has an active research component reported in a number of publications written in a medical genre and appearing in respected medical journals (Neuner 2008; Ertl et al. 2010; Ertl et al. 2011; Neuner et al. 2012).

In many ways, it looks as if Northern Uganda has been incorporated into the empire of trauma of which Fassin and Rechtman write (Fassin and Rechtman 2009). The humanitarian support to nearly 2 million people in the camps that comprised food rations, water supplies, nursery and primary schools, medical care, and a host of training sessions on gender equity and human rights came to include humanitarian psychology. The movement to recognise and treat trauma was carried by NGOs. The Alderman Foundation and Vivo, unlike Médicins sans Frontières and Médicins du Monde of which Fassin and Rechtman write, do not depend on foreign doctors to do clinical work. Instead, they trained hundreds of lay counsellors, which was probably a more effective way of spreading the repertoire of trauma than relying on a small number of professionals. In practical terms, trauma was most effectively communicable to clients by people who were fluent in Acholi.

Fassin and Rechtman see the rapid expansion of trauma in relation to the changing moral landscape of the Global North (Fassin and

Rechtman 2009). In the space of a decade or two, the figure of victim has emerged, deserving of sympathy, support, and even compensation for suffering caused by violence. They suggest that there has even occurred a conflation of perpetrator and victim, in that both may suffer from experiencing a terrible event. This obviously has political as well as moral implications. Trauma fits usefully in the particular situation of the LRA war, where children were abducted, committed brutalities as LRA fighters, and then had to come home to 'reintegration'. In the reception centres, they were counselled to understand that they were not responsible for what they saw and did because they acted under duress. This was the way they learned to tell their stories, even if they sometimes felt and talked otherwise (Akello et al. 2006; Verma 2012). The LRA conflict was a civil war; atrocities were committed by kinsmen and neighbours with whom one had to go on living (Meinert et al. 2014; Whyte et al. 2015). There was popular support for amnesty and much concern about the difficulties that returnees met when they tried to resume life in the camps and later in the villages. Sympathising with and supporting them as victims was helpful and may be one of the reasons why the repertoire of trauma was appealing and why it spread.

Yet seen from Wilma's kitchen, from the homes of thousands of families trying to help their relatives with frightening disabling conditions, and from the hospitals and health centres charged with their treatment, the empire is not so firmly established. Yes, the repertoire of trauma has been appropriated and yes, treatment of PTSD seems helpful for some. However, diagnosis and treatment of PTSD are largely dependent on humanitarian assistance, mostly administered through NGOs. These efforts are patchy and short term. PTSD is little visible in government health facilities (Whyte et al. 2015), even in those that have mental health clinics run by psychiatric nurses and clinical officers (medical assistants). Yet the public health system is widely available and persists, while NGO projects come and go. Thus, the apparatus for spreading and implementing the repertoire of trauma treatment is not strong and sustainable.

It is also noticeable that the repertoires of trauma and victimisation are not appropriated evenly by all in Northern Uganda. In a study of the return process of adult ex-LRA combatants, Odong points out that the receiving communities reacted very differently towards returnees who had held high rank positions in the rebel army (Odong 2014). They were generally not perceived as traumatised victims by their families and communities; in fact, they often faced stigmatisation and exclusion. So even though the ideas of trauma and conflation of perpetrator and victim seem widespread, these ideas are appropriated in a differentiated and micro-politically sensitive manner.

## The co-existence of *cen* and trauma[4]

The new repertoire of trauma took hold in a landscape where repertoires of *cen* were well-established and spreading. They now exist side by side. Their parallels and overlaps intrigue researchers, are recognised by clinicians, and provide possibilities for patients and their families.

Psychologists recognise in *cen* many of the assumptions found in PTSD about violence, memory, and certain symptoms of extreme anxiety. Harlacher, who wrote a PhD thesis on Acholi beliefs from the viewpoint of Western psychology, discusses the symptoms called *ajiji,* commonly associated with *cen* possession (Harlacher 2009). *Ajiji* follows on frightening experiences of violence. It includes intense fear, nightmares, reliving the experience, aggression, and distraction. Harlacher compares these symptoms one by one with the criteria for PTSD in the Diagnostic and Statistical Manual and finds substantial overlap.

A team of psychologists (Neuner et al. 2012) working with Vivo conducted an epidemiological study of *cen* possession and its correlation with other mental health measures. Carried out in 2007 and 2008, it surveyed a representative sample of 1,113 Acholi people between 12 and 25 years of age. Strikingly, 43 per cent had been abducted by the LRA, although some for only a few hours. The researchers developed a *Cen* Spirit Possession Scale to measure prevalence and intensity of possession by *cen*. High levels were found among 14.3 per cent of the abductees and 3.7 per cent of those never abducted. Among those with high levels of *cen* possession, 44.5 per cent met criteria for PTSD, while only 9.8 per cent of those with low levels or no *cen* possession were diagnosed with PTSD. The authors conclude that in the terms of the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-V), possession state disorder is among the most common mental diseases of youth in Acholiland. Risk factors for *cen* possession were exposure to traumatic events, female gender, extreme poverty and low level of education. Although Harlacher worked with case accounts and ethnographic material (Harlacher 2009), while Neuner and colleagues made a quantitative study (Neuner et al. 2012), there was agreement on the overlap between *cen* and PTSD. In this, the researchers all share the growing interest in the relationship between psychiatric diagnoses of traumatic memory and cultural variations on the same theme (Kenny 1996).

The biomedical health workers in Acholiland who offer treatment for mental health problems recognise the importance of *cen* for their patients. At the Alderman clinic, the psychiatric nurse remarked that most of their clients had tried other treatment before, mainly treatment

for *cen*. He said some went to church for help, but 70 per cent sought *ajwaki*.[5] The nurse explained that *cen* and PTSD are the same thing. 'PTSD is our modified language for those who have gone to school. The community takes it as *cen*. They mean the same.' His colleague at Awach Health Centre IV agreed. Both said that they translated PTSD as *ajiji*, the recurring image of terrifying events. They did not try to dissuade patients about *cen*, but encouraged them to try the hospital medicine to see if it worked. If not, they could go back to the *ajwaka* or try prayer and healing in church. Thus, despite the overlap between *cen* and PTSD, there was an emphasis on difference in treatment and recognition that patients were most interested in cures.

Patients and families also juggled the co-existing repertoires of trauma and *cen*. Some people, like Oloya, took hospital medicine while still entertaining the possibility of *cen* and taking herbal medicines to 'cool it'. Alice explained that her problems started in the camp. She would feel that something was suffocating her at night, and she would 'walk anyhowly' (aimlessly), keep silent, and refuse to eat. Or she saw visions of people moving in long lines, some with bicycles. One *ajwaka* told Alice that she had encountered *cen* in the camp; they offered an animal for it, but there was no improvement. Another *ajwaka* revealed that her husband's brother had killed his wife and hung up her body to look like suicide. The *cen* of that murdered woman affected Alice because it wanted to make itself known and to demand that compensation be paid. The family did pay, and Alice no longer walks anyhowly. 'But the *cen* made me lose sense, and now I still have a mental problem. I started getting medicine from the hospital when I lost my mother in 2001.' She brought out a small envelope of amitriptyline. When Susan asked if she had ever heard of trauma, Alice replied promptly, 'Oh yes, I have it myself. When you overthink, it can disorganise your brain.' Alice explained that TPO staff had told her she had trauma, given her counselling, and connected her to the health centre where she continued to get refills of medicine. Asked if anything bad had happened to her during the war, she said that she saw a dead person, her husband's father's brother. The rebels had cut his head with an axe so it looked terrible. For Alice, as for many others, there were several *cen* possibilities: the *cen* from the camp, the murdered wife made to look like a suicide, and the victim of an LRA axe. Now the pharmaceutical medicine for trauma was helping, but she still believed she had been affected by *cen*.

The afflicted individuals and family members with whom we spoke often seemed to consider possibilities in a subjunctive mode of trying out, hope, puzzlement, and doubt. Irene told of her son Onek, who started

acting strangely some years after he returned from the bush. He would sit quietly and suddenly cry, 'I did not want to kill.' They did a traditional ceremony, slaughtering a goat, to release him from *cen* and it helped for some time. Then he took to leaving home early and staying in the bush, or walking about silently or sitting for hours on a chair; he refused food and lost weight. They brought him to hospital where he was given some medicine that helped for a while, but then he did not want to continue with the drugs. Irene thinks it is *cen*. It seems he killed someone while he was with the LRA. She considers her options. Maybe hospital drugs can help this thing? Or maybe they need to cleanse him again. She does not know.

Edith was affected herself, as she recounted, speaking too quickly and looking uneasy. She could forget everything in this world and just sit. They tried many *ajwaki* and offered goats, chickens, and money. Finally, she followed her husband's advice to go to church and get saved, but still the strange spells continued. She went to hospital and took medicine for 2 months. When there was no change, the health worker said she need not continue with medicine and that it was better to keep praying. One *ajwaka* said it was something her co-wife had sent, but she tended to think it was *cen*. When Lotte asked if it might be 'trauma', Edith remarked, 'If it was trauma, the drugs would have worked.'

The repertoires of both *cen* and trauma continue to spread in part because of the way people keep on trying them out. When attempts with one fail, the other offers a way forward.

## Co-morbidity and syndemics

One family case that we followed over 3 years (August 2011–August 2014) allowed us the opportunity to explore how searches for *cen* and trauma treatment play out in a family context over time and how they are used in situations of multiple problems.

Adong is a widow in her 50s, a mother and a grandmother. When we first met her in 2011, she had recently exhumed the bodies of five family members from the Internally Displaced People (IDP) camp and reburied them at home. Her family was disturbed by continuous, serious problems, and she wanted to find out how to solve the issues and find peace in the home. The worst case was one of Adong's grown sons who had been abducted for 3 years during the war. When he came back home he had changed and Adong thought that maybe he was afflicted by *cen*. He escaped from the LRA alone, came directly home and did not go through an NGO reception centre. His behaviour was unpredictable.

He was angry, given to alcohol and marijuana, acted crazy and threatened his mother, sometimes even at night. Adong's friends were telling her to take her son to an *ajwaka*, but she did not want to. She was a saved person and preferred praying for her family in church. The son had not been to the health centre, but Adong hoped that one of his friends could persuade him to go for treatment of trauma. The 10-year-old son of this son was also mentally unwell and behaved strangely, but he had never been abducted or experienced serious violence, so Adong was wondering what was affecting the family.

Her daughter, who was abducted when she was 13 and stayed with the rebels for 3 years, had relatively fewer problems. She was rescued by the Uganda People's Defence Forces (UPDF) in Sudan and brought to Gulu by airplane with two children she had given birth to in the bush. The family heard her name announced on the radio and came to pick her up from the army barracks. The daughter was usually well behaved, but if she got into a quarrel with someone, she might threaten the other person saying that she could easily kill them. The son fought with the daughter, who complained that her brother's problem 'started from the bush' where he had seen and done bad things. Adong thought that her son might have killed someone in the bush, but he did not want to talk about it.

The next time we saw Adong, she had moved to her father's home because the 'traumatised' son kept disturbing her, beating her and telling her to go away. The grandson who also had a mental problem, or perhaps epilepsy, was not doing well, but the 'traumatised' son would not let Adong care for the grandchild and take him to the health centre. The family situation was further complicated by an ongoing land conflict between two clans. All Adong's sons were on police bond because they had gone to fight the opponents. Adong and her late husband's brother were the only people who knew the real boundaries. She had not told her sons about the boundaries because they had 'treated her badly' and the 'traumatised son' had even threatened her with an axe.

In 2012, Adong managed to take her grandson to the health clinic in Awach, where he was given medicine, but there was no remarkable change in his condition. The health worker had told them to come back if the medicine did not work, and he had asked her whether this problem was common in their clan, so she doubted that medicine could cure him. Adong thought there might be 'something running in her husband's clan'. She was wondering if it was something inherited in the genes or *cen* following the clan.

The next year she moved back to her marital home and the family gave up the land case, surrendering to the other clan. The grandson was referred to Gulu main hospital and the health workers said that he had a 'mental' problem (*cim*, epilepsy), but even the medicine from there did not help. The grandson moved to his mother's place, but Adong was still worried about him.

When we last saw her in August 2014, Adong seemed satisfied with the recent maize harvest and most of her grandchildren were thriving. However, the problems with the 'traumatised son' and the grandson continued, and her daughter's husband had divorced her because his family complained that she was too rude. On top of these problems, Adong's house had fallen down. Lightening had struck the house while she was inside with her daughter and grandchildren. A fire started, the house collapsed on them, and the daughter had a shock because she 'still had that trauma problem'.

'No one was badly injured, only because I don't have a problem with anyone. My house was clean [free of evil charms],' Adong pointed out. She reasoned that someone had been working with an *ajwaka* to send the lightening to her house. Other family members wanted an *ajwaka* to come and 'release those things'. Adong was suggesting that they get a priest to come and pray, even though she had not been praying in church since January. She was disappointed because she had prayed hard for the son, the daughter and the grandson, but there was no improvement. The grandson was getting worse; he did not eat and had even stopped walking. The son was still aggressive and had divorced another wife.

One of the striking issues in Adong's family is the multitude of, and connections between, problems and afflictions. At an individual clinical level, this may be recognised as co-morbidity of PTSD, neurological and psychological disorders, alcoholism and other drug abuse. Yet for much of our material, it seems more relevant to consider the family as the unit of analysis, and disorders as both biological and social. Several members are afflicted at the same time, and these people and their problems influence and enforce each other.

Singer and Clair have suggested a syndemic approach to analyse how various epidemics are entwined and mutually enforcing at biological and population levels due to harmful social conditions and injurious social connections (Singer and Clair 2003, 429). We suggest focusing on intermediary levels, in our case the family, to understand how social conditions and connections play into the equation. Singer and Clair describe synergetic effects of alcohol abuse and HIV infection on morbidity and mortality for patients with HIV co-infection (Prakesh et al. cited in Singer

and Clair 2003, 530). Similarly, we see synergetic effects of alcohol abuse and behavioural disorders on the social health of families, and furthermore how afflicted individuals in a family affect each other. Thinking about trauma and *cen* as repertoires for dealing with syndemics at the family level allows us to foreground social dynamics. Adong's family problems are caused by several contributing factors that are epidemic in themselves.

War can be regarded as a form of epidemic violence and the war in Northern Uganda was no exception. Patterns of LRA rebel attacks, massacres, and UPDF responses followed certain rhythms and escalations, both endemic and epidemic. Violent conflict is known to spread socially and geographically, and so-called fragile states with ongoing conflict may therefore be considered contagious and dangerous to their neighbours (Harpviken 2010). The young people who were abducted into the LRA describe their experiences of, and participation in, violence as part of a larger movement they could not control, but got enrolled in. The brutalities that Adong's son and daughter experienced and/or committed during their abductions were part of this epidemic of violence. The son's alcoholism is part of another well-recognised epidemic phenomenon in post-conflict Northern Uganda (Roberts et al. 2011). Land conflicts like the one Adong's family was involved in, as well as other kinds of land conflicts, have erupted in Acholiland after the war on an epidemic scale (M. Whyte et al. 2013). The mistrust between Adong and her sons regarding the land boundaries also seems to be part of a spreading social atmosphere in Northern Uganda after the war (Meinert 2014). The AIDS epidemic and higher rates of morbidity and child mortality in the camps during the war also contributed to syndemic effects. These various epidemics and increased disorders, as well as other factors, form the syndemic to which *cen* and trauma respond as possible ways of ordering problems.

A biomedical perspective on PTSD would foreground the damage to the individual brain during traumatic events, and would regard the other factors merely as 'triggers' of disease. The syndemic concept was developed in response to this dominant biomedical conception of diseases as distinct entities in nature, located in specific organs, separate from other diseases and independent of the social and cultural contexts in which they are found (Singer 2010, 25). The syndemic perspective allows us to think about disease in relational rather than categorical terms, and consider the importance of interacting social (and environmental) conditions that promote the spread of disease. In syndemics, the

health effects of co-morbid conditions are not additive, but multiplicative (Singer 2010, 26).

We have written of *cen* and trauma as repertoires, ideas and discourses that can be enacted to deal with problems and make them more understandable. However, for families in the midst of difficulties, *cen* and trauma are conditions in themselves. Not only do they seem to pile up with other social problems, they are also generative of some of these problems. For families, *cen* and trauma create and contribute to cases of domestic violence, child neglect, land conflicts and other forms of conflict. The violence of war transforms through *cen* and trauma into other forms of violence. It may make little sense to establish precise links between cause and effects in these problems because they are so intertwined. Fixing one problem (traumatised brains) is no magic bullet that solves all. Broader multi-sector approaches are needed.

We might ask whether it matters if one thinks about trauma and *cen* as repertoires, as syndemic phenomena, or as cases of co-morbidity with primary trauma and secondary trigger factors. It matters for the perception of what kind of response is needed and how this gets organised (or not). Miller and Rasmussen advocate for a psychosocial approach in which a focus on 'daily stressors' is equally important as the focus on traumatic events themselves. Based on this they argue for broader intervention programmes that aim at improving a variety of social conditions (Miller and Rasmussen 2010). Neuner, Ertl and colleagues, who work through Vivo in Northern Uganda, prioritise trauma-focused therapy (in their case narrative exposure therapy) because this has been scientifically proven to be an effective way of dealing with PTSD (Neuner 2010; Ertl et al. 2010). The Vivo group argues convincingly that a small organisation cannot gain expertise in what they do if they have to work in several sectors. From an NGO point of view, it may be more satisfying to be able to prove that you are doing something about the specific problem (PTSD) that you set out to solve. If we take Adong's family or some of the others we have spoken to as a point of departure, it is clear that trauma-focused therapy would only solve a fraction of the intertwined problems in a family. However, this fraction might make a difference in the whole configuration.

The other issue we would like to highlight in Adong's story, which is characteristic in many cases, is the pragmatics and micro-politics of finding solutions. If *cen* and trauma may be different repertoires for dealing with the same kinds of afflictions, it is important to underscore that they have micro-political implications for the actors involved. Different members of the same family have different views on their efficacy; for

some, *cen* ideas and practices are unenlightened and unchristian. Even the same person may hold different views and try different possibilities over time. Finding out about problems, establishing diagnoses and organising solutions are often complicated social processes and those who are afflicted may not be interested in the kind of help available. In some areas, as in Awach sub-county, only few options exist. They do not include narrative exposure therapy, but a rather overburdened health centre that dispenses amitriptyline, *ajwaki* who divine and propose animal offerings and churches where people can pray. Few (like Adong) are dogmatic and exclusive believers in 'hospital', 'traditional' or 'church' therapy, but search for possible solutions and try out the options available. If one of the strategies turns out to work, then the therapeutic journey comes to an end. However, in most cases we have come across, the search for solutions seems to be ongoing.

## A syndemic of problems

We began by asking if and how trauma might take hold and spread in Northern Uganda and we tried to answer the question by examining how trauma as a repertoire was appropriated within a local landscape where *cen* was also spreading. We considered both trauma and *cen* to be potential plans of action to which concerned families might turn for help with grave problems. Diverging from and complementing the focus of Fassin and Rechtman, we considered the possibility of an 'empire of trauma' from the viewpoint of the remote territories rather than the metropole. We thought that an empire would not only reflect shifting moral sensibilities at the centre. To be considered an empire, to exist and be sustainable, it should also provide solutions that people actually use in managing 'dis-ease'. There would be a treatment infrastructure that provides acknowledged relief in a given territory of the empire. On these grounds, we found that the hegemony of trauma was questionable. The insufficiency of trauma as diagnosis and treatment of the problems people experience is reflected in the spread of the older repertoire of *cen* as a possible way forward.

The very real epidemic of problems that people in Northern Uganda confront is propelled by vicious circles of violence that keep affecting families long after the war has ended. Rather than seeking to trace 'an empire of trauma', our approach has been ethnographic, starting with people such as Wilma in her kitchen. From this perspective, we see families contaminated by problems and violence. Both trauma and *cen* are communicable in this post-war landscape.

## Notes

1. 'Nuer told me that a man who has witnessed a killing, though he had no part in it, yet if he keeps silence, will suffer misfortune because it is like as though he had hidden the [dead] man.' (Evans-Pritchard 1956,174).
2. Acholi men experienced modern warfare serving in the King's African Rifles in the Second World War. Behrend cites Okot p'Bitek on the religious crisis provoked by the death of men in faraway lands and the fear that they would become 'bad ghosts' because their bodies were 'left in the wilderness' rather than buried at home (Behrend 1999, 110).
3. The foundation also supports two other similar clinics in Northern Uganda.
4. An interesting parallel to the co-existence of trauma and *cen* is found in a study of nightmares and trauma in post-conflict Aceh by Grayman and colleagues. With findings from a large qualitative and quantitative field research project, they point out that even though 'nightmares', which are perceived to be the work of mischievous spirits called *jin*, are not reported as part of PTSD symptoms, those who are diagnosed with PTSD are also more likely to experience *jin* 'nightmares'(Grayman et al. 2009).
5. This contrasts with the finding by Neuner et al. (2012) that 70 per cent had gone to a church or priest for healing.

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# Chapter 9
# Extinction and Time amid Climate Change or What is a Horizon?

Adriana Petryna

How is extinction being understood, witnessed, and debated in the early twenty-first century? What are the limits of determinism in conceiving its complexity? What other sorts of useful imaginaries, past and present, grapple with increasingly unpredictable and physically incoherent realities linked to a changing climate? These are some of the questions this essay addresses as it critically explores how the pinning of life within a predictable or deterministic process obstructs scientific reasoning about how ecosystems come under threat in an age of climate change. Specifically, it addresses the problem of surprising, even catastrophic, shifts in nature's ecologies, and explores some of the epistemological and moral complexities of an emerging 'abrupt change' climate science. Such complexities, no doubt, signal biodeterminism's end. However, what is at stake in this end? As this essay suggests, it is no longer just the work of genetic-environmental interactions or a more general calling into question of the universality of biological truth. Rather, it is the difficulty, and necessity, of horizoning work, or a distinct kind of human labour in which the fate of entire systems (be they organisms, ecologies, or worlds) is at stake.

## Crossing points of no return

Marten Scheffer, a well-known Dutch lake ecologist, picks up a flask of clear water containing *Daphnia* (water fleas), one of hundreds of similar flasks filled with zooplankton and cyanobacteria sitting on the white shelves of his laboratory at Wageningen University in the Netherlands. He

shows me a small steel object (a microenvironment) holding a laser beam and some organic lake matter. He jokingly calls this microenvironment 'the ICU of water fleas'. In one experiment, Scheffer and a doctoral student of his are measuring the time it takes for an algae microecosystem to recover from slowly deteriorating environmental conditions (a slight temperature increase in this case). After each increase the microecosystem's rate of recovery will begin a 'critical slowing down', tending toward a point of irreversible non-recovery. At this stage, smaller increments of temperature increase will begin to trigger more qualitative shifts. Before this happens, however, the ecosystem will 'flicker',[1] jumping undecidedly for a while between 'alternative stable states,' before it loses resilience or free-falls into 'extinction'.

What is extinction? And what do lakes, water fleas, and algae have in common? They are communities of living organisms that are said to have observable tipping points, or points of no return that result from small perturbations that can set off radical change, what in contemporary ecology are known as regime shifts, or a rapid alteration in the organisation and dynamics of ecosystems, with protracted outcomes.[2] In his classic essay about lake life, entitled 'The Lake as a Microcosm', Stephen Forbes, a founder of aquatic ecosystem science, mused on the properties of regime shifts this way: 'The animals of such a body of water are, as a whole, remarkably isolated, closely related among themselves in all their interests, but so far independent of the land about them that if every terrestrial animal were suddenly annihilated, *it would doubtless be long before* the general multitude of the inhabitants of the lake would feel the effects of this event in any important way.'[3]

Forbes highlights an uncertain time trajectory, from total isolation to total surprise, inherent in the concept of an ecological regime shift. Rapid modifications in ecosystem dynamics, their cause-and-effect relations, are invisible to the lake organisms themselves and introduce an 'invisible present' with respect to their sensing demise.[4] This work is one of many experimental efforts to reconcile the timing of such shifts with current bodies of scientific knowledge.[5] Such research inspired the 2013 US. National Academy of Sciences report, *Abrupt Impacts of Climate Change: Anticipating surprises*, which called for substantial funding for a new 'abrupt change' climate science that could help recognise signs (like flickering) thought to portend potentially catastrophic changes in a variety of vulnerable ecosystems. While much progress has been made in predicting sea-level rise and tracking the paths of hurricanes, for example, the potential for destructively surprising regime shifts is now recognised as very real.[6]

The kinds of changes at stake are familiar: rising temperatures, stronger storms, increased fire frequencies, decreases in Arctic sea ice. Many of these changes are not gradual, but are happening abruptly or within much shorter-than-projected timescales (within one person or professional's lifetime or a few years and decades, not centuries). According to the US National Oceanic and Atmospheric Administration (NOAA) charged with tracking atmospheric and oceanic changes, the years 2010–2019 constitute a 'landmark decade' in terms of disaster-related costs. Droughts, wildfires, hurricanes, and tornadoes and other natural disasters have been more severe or frequent and less foreseeable than in the past, disproportionately hurting poorer regions and marginalised communities. That decade (as compared to the previous decade) saw double the number of 'billion-dollar disasters': the signs of 'shift[ing] so far into a new climate regime that probabilities have been turned on their head.'[7] Indeed, what preoccupies most scientists is not proving the existence of climate change, that is a settled case, but of finding the tools of ensuring existence in the face of undeniable threat.

What's new about these changes? To date, much of the research on the physical climate has focused on linear extrapolations from recent history. Change, be it in biology, ecology, economics, or statistics, has often been predicated on the assumption of a *smooth* transition. Considerations of stair-step, non-linear or abrupt change – and how they can take on the 'catastrophic' form that they do – occupy the margins of statistical significance. Linear models can also inflate senses of agency and human control. In climate science, for example, there has been an assumption that 'slow [or gradual] processes pose small risks' and that 'a choice can always be made to quickly reduce emissions and thereby reverse any harm within a few years or decades'.[8] In economics models discounting future damages assume that time can be bought. Yet mechanisms of temporal discounting avoid the problem of possible irreversible damage. Furthermore, a built-in assumption of stability in social and economic systems may not hold. There are myths in ecology too that perpetuate an inflated sense of control, one being what I think of as a myth of infinite adaptability. Noting this myth and its ironies, eminent evolutionary ecologist Simon Levin at Princeton told me: 'There's no evolution working at [some] level to make sure that the [earth] system is preserved. So, we may be filling up – we are filling up the atmosphere – with pollutants and greenhouse gases and things of that sort. Maybe we'll survive that, but maybe we won't, there's no mechanism … We may be adapting ourselves to extinction.'[9]

In short, the human adaptive calculus is alarmingly off on many levels. As with Forbes' doomed fish, it lacks a reference point around

which to orient an expectation (of survival). While the fish perish in their sensory myopia, humans have something more than 'happy' isolation or a stark surrender (to inevitability) as their options. There is work to be done that I have been calling horizoning work in opening up time or, rather, in gaining the conditions for responsiveness in a race against time. As doubt-mongering noise of climate deniers in the US continues, a culture of common sense that can contend with the 'large realm of the given and undeniable' is yet to be crafted.[10] The National Academies Report's principal author, geoscientist James White, underscored such sentiments and needs when he stated in a public briefing that scientists must address 'areas of observation *where we are largely blind* … As a scientist, my hope is that we can study the planet well enough, monitor it well enough, understand it well enough, that we're not going to be blindsided. As a realist, I'm pretty sure we're going to be blindsided.' Blindsidedness, White states, is now a structural feature of climate change science and policy.[11] Nature's old resiliencies in the face of pressure are no longer a given and scientists and policymakers alike say we need radically new maps of potential imminent threats, or, in the language of contemporary regime shift science, of tipping points and points of no return.

The idea of a clear and distinct threshold or a tipping point (popularised by Malcolm Gladwell's book of the same name (Gladwell 2002)) has an overly seductive precision in the ecological domain. However, in the material sciences (and in engineering especially), the state of knowledge about various 'thresholds' of instability and qualitative change is well described. In living systems, a tipping point is a mathematical characterisation and component of what French topologist René Thom (1923–2002) called 'structural stability' (Thom 1975). In revealing some of the ways systems lose 'resilience', tipping points demarcate borders between the structurally stable, 'those things that are knowable,'[12] and what lies beyond this knowability, or the things that scientists have yet to learn that would satisfactorily account for the stability of forms. Tipping points do not reveal *why* these systems evolve or how they adapt, but they do tell us something about how a system remains stable at all. 'Regime shifting', 'catastrophic folds', and 'alternative stable states' are just a few of the exuberant, René Thom-inspired terms to point to these enigmas (which, to be sure, are somewhat on the edge of mainstream evolutionary ecology). Many ecologists are employing them today to mathematically describe something as benign as how a certain snail shell is not a type of clam shell, or something as terrifying as how familiar habitats and forms of life can give way, without much warning, to entirely new and unfamiliar ecological states.

Mathematically inspired ecologists are actively applying Thom's 'catastrophe theory' to trace the complex 'locking in' of different forms, states and ecologies.[13] The question of tipping points, or the dynamic of the actual transition or 'flip', exceeds what theories of natural selection or models of host–predator interactions can make sense of, and it makes extinction, near-extinction, and the 'hour' of extinction for that matter not at all transparent phenomena.[14] In other words, tipping points are epistemologically charged constructs that mark a *hiatus* of expert knowledge about what (alternate states) exist or co-exist once certain critical thresholds are crossed and about the forms futures will take.

It should be noted that the past is replete with evidence of abrupt shifts that are without signs of apparent proximate causes. The Sahara Desert, for example, was made up of wetlands 6,000 years ago, until it switched to a desert-like condition. My anthropological investigation into the models and tools that are being developed to understand and manage environmental risks has taken me to various scientific fields where tipping points or various threshold transitions are being quantified (for instance, in shallow lake ecology, deep lake ecology, and coral reef ecology). As I explore the science of 'critical transitions', I ask about where that science comes from historically and how it is being applied to ecological concepts of overstressed nature. In the process, I am crafting a genealogy of a different pursuit of form in the twentieth century among a line of scientific iconoclasts who did not accept the evolutionary modality of minute variation through gradual differentiation. Among others, René Thom, whose catastrophe theory was once highly discredited, is now being vindicated.

Indeed, ecosystem changes are happening with surprising speed or within much shorter-than-projected timescales. In exploring both temporal and topological aspects of tipping points (this side of the tipping point, opposite the blind side), we also grapple with conditions in which given knowledge bases are insufficient more broadly. Within an undemarcated space of abrupt ecological change, questions of how far or near or over vital thresholds we are, call for new experimental and projective media. In what follows, I address the problem of surprising, even catastrophic, shifts in nature's ecologies, tracing some antecedents of an emerging regime shift science. Then I explore dimensions of this science (linked to temporal and topological uncertainties of such shifts) and illustrate some of its challenges and public policy stakes. Lastly, I probe how an unfamiliar and even 'runaway' nature poses problems of faltering projection and of projective deficit. In this context, I offer the idea of horizoning work as a new kind of projective medium for the problem-space of survival at various thresholds of irreversible change.

## On the nature of 'catastrophic' forms

The problem of surprising or abrupt shifts, ultimately, goes back to a profoundly heterodox (at least for its time), mathematical science of form – morphology.[15] This is a division of science that was relegated to an intellectual periphery with the twentieth century rise of scientific determinism and molecular-genetic techniques which fixed on reduction and mechanism as founding principles of efficient cause. Part of René Thom's inspiration begins with those who attempted to theorise evolution against teleological Darwinian (and later molecularised neo-Darwinian) determinisms, and in terms of an 'ordinary process of causality', that is, the imprints, stresses, and compressions, of outside physical forces. The work of Scottish zoologist, mathematician and classicist, D'Arcy Thompson (1860–1948) is exemplary in this respect. Thompson pioneered the scientific explanation of morphogenesis and what he believed he could illustrate graphically: the logic of shape change in living forms.

In his classic 1917 book, *On Growth and Form*, Thompson elaborated on what he believed were purely *mechanical* forces acting on and shaping bodies. He showed, for example, that the change from, let's say, a puffer fish to an ocean sunfish (mola mola) or vice versa can be explained by the conversion of a rectangular coordinate logic, in this instance, into a curvilinear one (Figure 9.1). The coordinate system

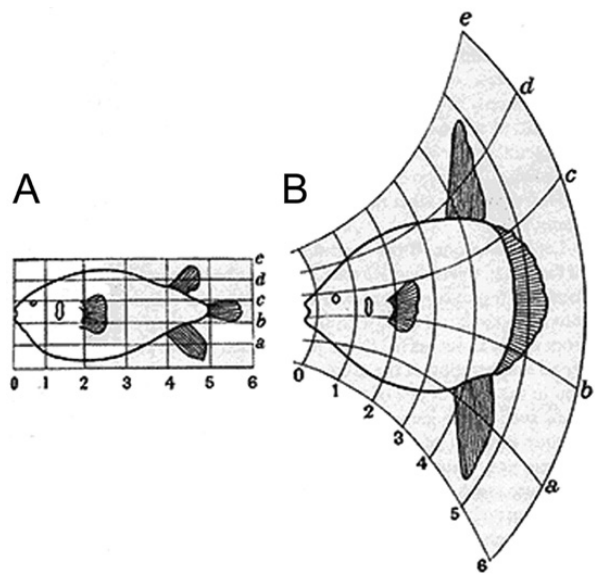


**Figure 9.1** Transformation of a puffer fish into an ocean sunfish (*mola mola*). Source: *On Growth and Form* (Thompson 1917).

expands the posterior section of the puffer fish to create corresponding points between both the puffer and mola mola. Thompson was mainly interested in hypothesising the workings of virtual coordinate net in real space. That is, given the fields of physical forces that exist in the universe at different scales and at different places, certain morphologies and not others will emerge. This is a very idiosyncratic view of morphogenesis that, perhaps justifiably (from a Darwinian perspective), was thrown into the dustbin of history. 'The triumph of Darwinism,' Stephen Jay Gould once commented, 'did not assure an adequate treatment of form.' The prominent evolutionary theorist wrote admiringly of Thompson's work, but called his *On Growth and Form* an 'unusable masterpiece'.[16]

Thompson failed to ignite a research programme in his lifetime, but in asking by what 'equation of motion' an ocean sunfish morphs into puffer fish, a snail into a clam, etc., Thompson laid the groundwork for further developments in the mathematical study of growth and form. Twentieth-century British paleontologist, philosopher, and developmental biologist Conrad Waddington (who would collaborate and publish with René Thom), drew insights from D'Arcy Thompson's nets and theorised morphological processes in what he called epigenetic landscapes (Waddington 1957). Waddington coined epigenetics as a branch of biology that analyses the linkages between genes and their products that give rise to phenotypes.[17] His original idea was, like Thompson's, largely topological, pointing to possible physical evolutions of form via virtual constructs that would take decades for the scientific community to appreciate and test.

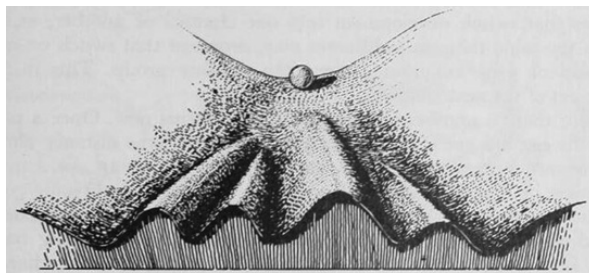

**Figure 9.2** 'The Epigenetic Landscape'. Source: Waddington, C. H. 1966. *Principles of Development and Differentiation*. New York and London: Macmillan. Wellcome Collection. CC BY-NC 4.0.

The epigenetic landscape illustrated the conceptual properties of a developing living system. Let us say the ball at the top (Figure 9.2) represents a cell, and it progresses along one valley or developmental pathway out of a possible set of pathways ('chreode'). At the terminus of each chreode is a discrete outcome of differentiation, and that outcome is in a 'stable state' (a crucial idea for later critical transitions ecologists). Once those balls reach their stability state, they are said to be in a state of so-called resilience.[18] Yet the 'stability cup' in which a ball turns into a tree, for example, can always 'flip' toward a different state and the tree can assume some other form. A sense of a (topological) accident, not a mechanistically pre-determined macroscopic whole, is brought to the centre of intellectualisation.

What René Thom (the catastrophe theorist who inspired research into 'critical transitions' or abrupt ecosystem changes) took from Waddington's epigenetic landscapes and Thompson's coordinate nets before him is a logic of abrupt change, which he attempted to formalise as a distinctive, if somewhat obscure, heuristic. Thom, attentive to the ridges of Waddington's landscape (right when something decides to become something else), redefined them as 'catastrophic bifurcations' that he made amenable to mathematical formulas of non-linear formal behaviour.

This brief excursus into the unorthodoxies of form represents one historical instance of an 'end of biodeterminism' (Napier 2014). Here, the 'nature' of catastrophic forms – how living forms stay stable and 'resilient,' or how they abruptly shift, change, or disappear – can be considered anew, as certain theoretical constructs used in ecology today highlight the peculiar behavioural and formal 'openness' of (eco)systems. While some ecosystems lack 'convincingly established' tipping points, recent abrupt and non-linear changes have prompted researchers to expand their toolkits for making sense of how near irreversible shifts may be.[19] In this research even signs of stabilisation are suspect. For example, a recent slowdown in the increase of the earth's surface temperature had been observed even though greenhouse gases have been accumulating in the atmosphere 'at a record pace'.[20] Was this slowdown mere business as usual, luck, or a sign that an ecosystem is drawing closer to some critical boundary?

## Navigating non-parametric worlds

In the scientific void of how 'surprises' come about, what is observed instead is an intricate superstructure of accumulating surprises, consisting of overlaid climate events whose net physical interactions and impacts are unknown. For example, in characterising key scientific challenges in

the wake of Hurricane Sandy, which caused severe damage in both the Caribbean and along the US Atlantic coast, Marcia McNutt, the former director of the US Geological Survey, stated: 'It is not the gradual rise of sea level that is going to get anyone. It is the combination of extreme events *superimposed on that gradual rise* … that will destroy our natural protection and offer much less protection for future storms.'[21] That is, any estimation of destruction in the future must be recalibrated in accordance with lowering baselines of protection in *entire* ecosystems. McNutt notes, 'We have already crossed a threshold. Superstorm Sandy was a threshold, and we crossed it.' The threshold here, however, is not only one of heightened physical danger, but of faltering projection and of limited human coordinating powers (leading to lost opportunities for enacting precautionary measures). Here, what scientists are used to calling a problem of uncertainty requiring more data may, in fact, be a complex system on the verge of collapse. The crossing-over McNutt refers to also suggests a potential for blindsidedness – not only of not knowing but of the potentially high cost of 'overfitting' new data within older models that themselves must be changed or discarded to deal with the climate change hyperobject.[22]

Yet the key to managing or conserving living ecosystems within this hyperobject may not be more knowledge, but the effective schematisation of the knowledge that already exists. In 2009, 29 internationally renowned scientists published a comprehensive assessment of the state of knowledge of nine earth systems (linked to climate change, biodiversity loss, biogeochemical change, ocean acidification, land use, freshwater contamination, ozone depletion, atmospheric aerosols, and chemical pollution) and identified their 'planetary boundaries', within which 'humanity can continue to develop and thrive' and beyond which 'abrupt or irreversible environmental changes' might ensue. According to the authors of the planetary boundaries concept, 'Our proposed boundaries are rough, first estimates, only surrounded by large uncertainties and knowledge gaps.'[23] While some boundaries have been clearly identified, the boundary for atmospheric aerosol loading cannot yet be determined. The climate-change critical threshold has already been transgressed, yet how far past that threshold is not known.

Importantly, such work diverges from an era of climate science in which, on the one hand, every grand scientific assessment of climate challenges cannot push too far or is 'larded with caveats'[24] or, on the other hand, in which every new disaster is regarded as a latest wake-up call. The planetary boundaries concept provides a crucial limit-image with which to make sense of the causal potential of human destructive action,

now stretching across dimensions of geologic time and global space, as well as a map of sorts to fathom this non-parametric world.

The work of demarcating safe distances from alleged points of no return can also invite danger and arrogance. Paul Ehrlich's 'Population Bomb' (1968) is a case in point, fueling hysteria in the 70s and 80s of the prospect of mass starvation from overpopulation and used to justify repressive reproductive policies. To some sceptics, the planetary boundaries concept might look, in fact, like a grand exercise in hubris. Detractors claim that there are plenty of ecosystems that lack early-warning signals.[25] Such signals can be said to be missing in other kinds of 'extinction' processes. The precise location of extinction boundaries separating the great geologic periods has confounded geologists. Prediction of time of imminent death to allow referral of cancer-stricken humans to a separate room remains elusive. Long before physiological tolerances to high temperatures predominate, other proximate factors can cause scenes of fatal 'temporal mismatch', as when hosts and predators do not migrate at a similar pace in response to warming. The tipping points that presumably lurk in bodies, ecosystems, and geologic records are literally intangible. Rather, the trajectories of species or habitat survival unfold in a chaotic 'borrowed time' and space.[26]

Indeed, efforts to establish planetary boundaries in the face of many unknowns depart from the previous modus operandi for quantifying risk – standard techniques of risk assessment based on probability, the maximisation of expected utility, cost-benefit calculation, or scenario forecasting. Embedding pre-constructed values and arbitrary endpoints, such techniques tend to leave ambiguity out. They isolate some aspect of uncertainty, narrow its scope, and thus offer only temporary cognitive control. As such, relatively short-term horizons are more conducive to strategic decision making. Even the time horizons that scientists employ in risk projections are fairly random. The well-known Stabilisation Wedges, for example, project out to 50 years (the typical span of a scientist's career). What about the cases in which there is no probabilistic data? Or those for which we have no way to know how seemingly random variables may take on value in the future? Or cases in which 'the relevant sources of uncertainty, are difficult to identify?'[27]

The concept of planetary boundaries doesn't need the absence of ambiguity to contend with unpredictable (or unquantifiable) wholes. One could say that the idea functions more like prevention in public health, inviting broad strategies rather than 'magic bullet' solutions.[28] We can never 'test' the efficacy of prevention strategies in advance, just as we will never know how many plagues, infections, or disasters have been

averted by our persistent reliance on them. In shifting the focus from old kinds of uncertainty (about the reality of climate change or whether humans cause it) to new kinds (related to over abundant ambiguities and related semi-empirical positioning of critical thresholds), the planetary boundaries concept embeds existing knowledge about climate change in a new qualitative dimension.

## Horizoning work

That the earth is a dynamic system capable of both gradual and exponential change suggests processes that, we might say, have been poorly horizoned so far. Rather than banishing uncertainties at our own peril, horizoning work turns them into schemes that can be held to long enough to keep the earth's forests, oceans, and biospheres intact. But how durable is that grip? How shall we reckon with nature's adaptive calculus and make our own? For example, what is the right target for stabilising long-term concentrations of carbon dioxide to avoid 'dangerous interference with the climate system'? Or, is it desirable to 'cap species extinctions at 10 times the background rate, as is being advised?'[29] The planetary boundaries cannot answer these questions, that is because their answers will always depend on some other unknown variables, including the 'complexities of interconnected slow and fast processes and feedbacks in the earth System' that will always make the answers partial.[30]

It is this space of partial knowledge that invites a potentially dangerous form of misrecognition about the nature of (borrowed) time and the future. Across disaster domains, we see ample evidence of how, for example, the arbitrary temporal horizoning of expected risk (as with, for example, 100-year-return periods in hurricane forecasting) or intervention 'overkill' (as with earlier attempts to control the weather) leaves the very problem of danger and its timing unaccounted for. In the context of this kind of epistemic uncertainty, there is a fascinating, if topically diverse, literature about efforts to invent shared temporality with runaway change in the hopes of restoring 'system' stabilisation. Be it navigation of treacherous seas or thinning ice, what escapes perception (a horizon line or a precarious patch of ice) is precisely what becomes an object of conditioned or acculturated thought.[31]

Historical and anthropological work on the intimacy of knowledge of collapsing ice sheets, glacier retreats, earthquake occurrences, or the

timing of any of these events that typically escapes calculation, is emerging.[32] To these we can attach a body of forgotten classic ethnographic texts on traditional navigation that show how navigators make the best of partial information and, at the very least, assure us that we are not alone in needing a better art of interference in worlds of physical incoherence. Of the Puluwat navigators of Micronesia, Thomas Gladwin wrote, '[T]he sea is a demanding master. No style of thinking will survive which cannot produce a usable product when survival is at stake.'[33] In a more contemporary illustration of navigation, anthropologist Kirsten Hastrup shows how Thule hunters of Northwest Greenland must navigate on thinning ice according to new diagrams (a 'diagrammatic imagination' that 'moves beyond calculation to orientation by other means of navigation'). There are, she notes, 'lots of lateral clues to the state of the sea-ice, and the hunters have to move by an implicit diagram of their interrelations'.[34] Such local knowledge suggests a form of self-preservation based not in more knowledge, but in an effective use of the pre-existing knowledge. This self-preservation aims to restore epistemic coherence amid conditions of potential incoherence, if only for an instant of stability for forward movement. What is tested in this recovered space of 'borrowed' time are techniques of projection affording real cognisance of jeopardy to whole systems, in this case, to human communities surviving on sea or ice.

The word horizon derives from the ancient Greek ὁρίζω (*horizō)*, meaning 'I mark out a boundary', and from ὅρος (*oros*), 'boundary' or 'landmark'. Across time and many cultures of expertise, people have used the horizon concept as a strategic point of reference in the navigation of different kinds of physically incoherent worlds. Renaissance architects used 'horizon lines' to properly orient objects in three-dimensional space. Early modern surveyors devised mercury-filled 'artificial horizons' to create an image of a level surface against which the 'inconstancy of the terrestrial horizon' can be judged.[35] Today, robotics engineers encode 'predictive horizons' in remote machines (such as extraterrestrial rovers) to allow for autonomous self-correction in the navigation of craterous conditions on Mars. In meeting such course-plotting challenges, data from the past is useful, but only up to a point. Precisely when prior experience is no longer useful and prediction capability derived from past or present information becomes misleading (or yields high computational cost or instability), a new 'predictive horizon' must be put into place.[36] Here the system (a boat, a lifeway, a future) to be stabilised takes precedence over the object of uncertainty to be known.

As these examples suggest, horizoning includes an array of calculative processes in the interface of 'system' survival and a blindsiding (or

crashing or disappearing) state. It involves working against projective deficit as well as testing and assembling appropriate 'scaling rules' for recognising and 'maintaining a safe distance from dangerous thresholds'.[37] Such work requires demarcation or 'incrementing', using known parameters, but it is also a practice of continuous self-correction *vis-à-vis* changing baselines of safety and knowable risk. In most extreme conditions, horizoning work entails a fine-tuned awareness of a system's exposure to jeopardy, without which navigators will inevitably be 'flying blind'. Horizons of all sorts have made complexity temporarily actionable within a particular human or technical frame. Horizon thinking 'makes good' on faulty or fleeting information and allows movement forward or prevention of a (literal) crash or disappearance of an entire system. The fact of entire trajectories, machines, or worlds being at stake is precisely what makes horizons so real.

## Biodeterminisms versus 'remote futures'

When the reality of abrupt change does not always conform to conventional expectations, and when 'there is no mechanism' of its rationalisation, it is no surprise that scientists and policymakers alike are in search of new theories. Today, various scientific communities are grappling with images of form-succession past critical thresholds; models are still largely anchored in temporal dynamics that are either overly gradual or arbitrarily set. Scientists working in the area of regime change puzzle over evolutionary questions not only in terms of adaptation, but also in terms of shifts into 'alternative stable states'. They are attempting to create a 'search image' that can travel along the frontiers of the observable and the unobservable, undermining notions of static equilibrium and linear change. This search image suggests that what scientists have been accustomed to calling an uncertainty problem requiring more data may, in fact, be a complex system on the edge of unforeseen collapse. This fact alone presents an ethical choice in scientific research, to provide more data about the fact of uncertainty or to provide reasonable schemes for navigating that uncertainty while also contending with given and undeniable risk. Within these complex realms, horizons present us initially with fleeting if somewhat arbitrary endpoints, where vision literally disappears. They shed this arbitrary quality and reveal their value in coordinating human movement in spite of always incomplete knowledge. One could say that arrival at a desired endpoint is their final product (and reward).

Horizons, in other words, make temporal and scalar potential out of the unpredictable, giving direction and affording movement. As the early progenitors of regime shift science suggested (Thompson, Waddington and Thom), abrupt changes in nature require knowledge as well as forms of speculation that resist the claim to a fully determined technique. The idea that one must dismantle something in order to understand is untenable in contemporary ecological worlds. In moving away from an established evolutionary telos or orderly nestings of the genetic/micro- and environment/macro-scales, they showed how a new ground for critical reflection in uncertain worlds is required. While today there is much critique of micro-reductionism in the natural and social sciences (the atom, the gene, the rational actor, and so forth), there is macro-reductionism in science too that keeps observers in a kind of horizonless myopia.[38] For example, biological systems are now said to have emergent macroscopic or macrosocial properties that determine their components. Individual 'agents' interact with each other according to 'altruistic' or 'selfish' agendas, motives, or algorithms that can ostensibly be derived from the aggregate behaviour of such phenomena as a school of fish, or a beehive. Epigenetics in its current incarnation is said to solve the nature–nurture debate 'that has divided life and social scientists for many years'.[39] However, Margaret Lock and others have argued that despite this apparent shift of focus beyond the molecular, the fetishisation of the gene (as well as the epigenome) continues, albeit in a macro-reductionist form.[40] Scientific macro-reductionism (as with micro-reductionism) contains an array of unsubstantiated onto-epistemological and moral claims about the social, humans, and animals alike.

As the editors in this volume suggest, the purpose of biodeterminism's critique 'is not to simply draw the pendulum towards the culture side' (Introduction, this volume). If there is any larger lesson to derive from the stark epistemic questions raised by ongoing ecological regime shifts accelerated by climate change, it is that the science of nature and the science of the social must be recaptured from current macro- and micro-reductionisms. As complex phenomena like behaviour and biology become 'fundamentally informational and statistical', the social breaks down into meaningless bits of data points to be repurposed for economic, health, and surveillance-driven prediction sciences and algorithms.[41] Worlds that are structurally misaligned with, and misunderstood within, these algorithms can become the target of more bias. Keeping check on what these algorithms create (natures) or prescribe (stereotypes/oppressive norms) remains crucial.

The problem of being blindsided by regime shifts within our envelopes of life is a serious one, challenging the 'Darwinist luggage of

adaptive evolution' (Introduction, this volume). Rather than jumping too often and too quickly to final scenarios, the trouble of blindsidedness is one worth 'staying with'.[42] It also echoes classic anthropological trouble linked to temporal distancing and a denial of shared or coeval time.[43] Critical transitions scientists and their forgotten or misunderstood forebears attempted to redefine temporal and spatial proximity to natural phenomena outside the biological dogmas of their time. The attempt to render nature as coeval with scientific inquiry was paramount for Conrad Waddington, for example. What he issued in his epigenetic landscapes was more than an 'environmental addendum' to genetic theories,[44] but what he called the need for a 'biologically useful topology' that could illuminate pathways of change in (what he called) 'remote futures'. His rebuke of dogmatic neo-Darwinist attachments of 'fitness coefficients to genotypes' came with vivid quips: 'If a horse is escaping from a tiger by running away, neither the tiger – nor anyone else – is interested in its genotype.'[45] Temporality and topology became key antidotes to the growing problem of biodeterminism and the objects it purported to describe.

Today this biodeterminism itself creates problems of projection or, rather, a looming projective deficit in which sudden, dramatic, or irreversible processes readily produce apocalyptic thinking. As I showed, there is a critical gap between knowledge of climate change phenomena and their interacting sources of uncertainty that engenders a runaway nature. In the process, not only has 'the uncertainty in the models used for prediction been underestimated',[46] but so has uncertainty in the ecological phenomena themselves. Such an unsafe distance from suspected points of ecological no return itself carries dangerous potential for misrecognition about the nature of borrowed time. Rapid modifications in ecosystem dynamics (and their cause-and-effect relations) form an invisible present with respect to a sensing of demise. Attuned to the existential hazards of such a present, I have drawn from scientific and anthropological modes of attention to argue for a distinct kind of intellectual and ethical work, a horizoning work, amid the uncertainties of time and physical worlds that are on edge.

## Notes

1. This activity is part of what is called a 'critical slowing-down' (Scheffer et al. 2009). ICU refers to an 'intensive care unit'.
2. See Carpenter 2003; Scheffer et al. 2001, 2009. $CO_2$ emissions are the cause today of significant human and ecological disruption. Their doubling in the next few decades demands better ways of apprehending the poorly understood thresholds of ecological regime shifts and species extinction.
3. Forbes 1887, my italics.
4. On the invisible present concept, see Magnuson 1990 and Petryna 2017.

5. At present, there is a 'wide gap' between available information on climate change 'and how that information is being framed in the context of risk and uncertainty' (Kunreuther et al. 2013, 2). For an excellent anthropological treatment of uncertainties in climate change models and their social life, see Hastrup and Skrydstrup 2013.
6. The literature on such shifts in ecosystems is vast. Some key texts include Scheffer et al. 2001, 2009; Lenton et al. 2008 and Steffen et al. 2018.
7. Smith 2020. Quote on probability from Weaver 2016.
8. See Solomon et al. 2009, 1708 and for a critique of gradual processes and bought time. On non-linear change, see NAS 2013.
9. Interview, July 2013, Princeton University. On a critique of built-in assumptions about stability, see Stern 2014, 449.
10. On denial, see Oreskes and Conway 2011. On the undeniable in common sense, see Geertz 1975, 75.
11. White. 2014, public briefing on 'Abrupt Impacts of Climate Change: Anticipating surprises'.
12. See Thom 1975, 7.
13. On locking in, see Hughes et al. 2013.
14. On host–predator interactions, see Cahill et al. 2012. On the lack of transparency of extinction phenomena, see Petryna 2013a and 2013b.
15. On the 'nature of catastrophic forms', see Petryna and Mitchell 2017.
16. See Gould 1971, 232, 253.
17. Waddington 1942a. On the practices of molecular epigenetics as they 'miniaturise' those causal interactions and the environment, see Margaret Lock 2013b.
18. Also see the work of ecologist C.S. Holling 1973.
19. See Lenton et al. 2008.
20. See Gillis 2013.
21. Marcia McNutt, public lecture, National Council for Science and the Environment, Disasters and Environment Conference, Washington, DC, January 2013.
22. With regard to older models, 'Formal approaches, such as the maximization of expected utility or benefit-cost analysis, are difficult to apply in the presence of ambiguity with respect to the distribution of future climate scenarios' (Kunreuther et al. 2013, 449)). On hyperobjects, see Morton 2013.
23. Rockström et al. 2009. Also see Steffen et al. 2018, a key follow-up essay on research on earth system trajectories.
24. See Brysse et al. 2013, 330.
25. Boettiger et al. 2013.
26. On extinction boundaries, see Fowell and Olsen 1993. On imminent death, see Hwang et al. 2013. On temporal mismatch, see Cahill et al. 2012. On borrowed time, see Hughes et al. 2013.
27. Kunreuther et al. 2013, 447.
28. On magic bullets, see Cueto 2013.
29. Nature 2009, 447.
30. See Röckstrom et al. 2009, 32.
31. On acculturated thought, see Geertz's notion of 'common sense'. Geertz writes, a person without common sense is someone for whom 'life is a series of scorchings he should have had the wit not merely to avoid but not to have stirred the flames for in the first place' (Geertz 1983, 76).
32. On how gaps in knowledge about climate phenomena are remediated by processes of expert elicitation, especially in the absence of complete knowledge about an impending danger, see O'Reilly 2017. On how climate change 'comes to matter' in the knowledge and experience of broader publics, see Callison 2014.
33. See Gladwin 1970, 232.
34. See Hastrup 2013, 93.
35. See Thomas 2004, 21.
36. See Parunak et al. 2007.
37. On scaling rules, see Griffen and Drake 2009. On safe distances, see Rockström et al. 2009, cited in Hughes et al. 2013, 6.
38. See Thom 1975, 155. On macro-reductionism, see DeLanda 2006, 4–5.
39. Thayer and Non 2015, 724.
40. Lock 2013b and this volume. As the epigenome explains less than half of exposure-related human harm, its scope is oversold and could be read as part of a further 'scientisation' of the social world. See Zakariya 2016.

41. On algorithms of oppression, see Eubanks 2018.
42. See Haraway 2016.
43. See Fabian 1983.
44. For a trenchant critique of the uses of environmental variables in the 'lure of the epigenome', see Lock 2013a.
45. See Waddington 1974, 33.
46. See Boyd 2012, 306.

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# Afterword: **Getting Closer?**

Anna Tsing

Something surprising has happened to social and cultural anthropology in recent years: a new rapprochement with the natural sciences. Suddenly, it is possible to read an article in anthropology and learn about the social lives of bacteria and the difference between those interactions with bacteriophages that kill the bacteria and those that offer them an advantage. Such departures from humanistic convention add a new excitement to the field; unexpected openings multiply. The contributors to this volume are developing a new kind of curiosity that brings them from the intricacies of epigenetics to the possibilities of critical ecological transitions. Furthermore, their voices blend with similar emergences across the field in which we are asked to engage with evolution, biological development, domestication, ecology, geology, climate science, and more (see, for example, Tsing et al. 2016). We are no longer just observers and critics of these sciences; suddenly, we are participants too.

Why have social and cultural anthropologists become so interested in the natural sciences? Despite proclamations of the new materialism, I don't think this was sparked by a turn in philosophy; many philosophies flourish within it. Instead, new problems and new developments in the natural sciences have caught the eye of anthropologists. In medical anthropology, the conjuncture between long-standing concerns with the social construction of illness and the emergence in biology of a newly vital science of epigenetics seems key. If gene expression is caught up in social history, are biologists ready for the insights of the social sciences? Does epigenetics segue into what we have been doing all along, or are biologists still missing the boat?

This volume begins with questions such as these and takes off into other biologies and ecologies in which social relations matter. What is the relationship between anthropology and these emerging sciences? Here I follow the chapters toward tentative answers.

## Do the new sciences of plasticity lead natural science practitioners toward the insights of anthropology?

Margaret Lock answers that question with a history of the concept of epigenetics. If epigenetics itself is a changeable beast, perhaps it meets our discipline in some places and not others. Indeed, one of her most striking findings is that the campaign *against* epigenetics is a modern one, a child of the late nineteenth and twentieth centuries. Biologists today revive older concepts shut out by modernity's preformationist essentialism. Jörg Niewöhner attacks the same problem through observation; molecular biologists, he finds, do believe in social relations but have an impoverished view of the social. David Napier and Adriana Petryna draw other sciences of plasticity into the story, adding tales of domestication and ecological modelling. They too adopt a 'yes and no' endorsement of these sciences, warning of dangers but clearly excited by possibilities.

Of course, this assumes a disciplinary autonomy from which to safely regard the other. What if proposition and critique, natural science and humanism, are intertwined? This conundrum has always vexed anthropology, and it seems to me that there is no simple answer, only a series of strategies.

## Might anthropological fieldwork on scientific turf raise problems already inside science and thus subject to prior engagement across the disciplines?

Mette Svendsen, studying the use of piglets as models for the care of premature human infants, quotes her scientist informants, '[W]e are your piglets.' By blurring the line between pigs and humans, her scientists also play with distinctions between the human and natural sciences. The questions Svendsen raises are already concerns of her informants; she articulates what they wonder. In speaking for them, her work is thus inside as much as outside the science and seems to suggest that biomedicine creates its own anthropologies by requiring modes of subject formation that transgress other cultural distinctions to become self-enclosed worlds. Anthropology might then be *inside* these forms of science and medicine; the job of the practitioner would be to uncover that component.

'Already inside' has been the productive conceit of a good deal of science studies. From such a standpoint, anthropology treads a careful line between knowing too much and knowing too little. It is possible to enter a maze with no exit. This has both enchantments and terrors as illuminated by other strategies in the volume.

## What anthropological findings push the new sciences into open dialogue?

In Northern Uganda, Lotte Meinert and Susan Reynolds Whyte explain that former militia fighters are often hounded by both trauma and vengeful spirits of the unquiet dead. Each requires a different set of diagnostic and treatment procedures; each offers a different ontology. Each challenges the other and yet they co-exist. To analyse ghosts and trauma together is difficult for biomedicine, yet it throws down a gauntlet that cannot be ignored. Anthropology, here, challenges all those who would limit their vision to the one without the other. Their findings provoke natural scientists to take note.

In such approaches, the worlds explored by anthropology are not co-extensive with those of biomedicine. The challenge thrown across the disciplines is empirical as much as philosophical; this allows the possibility of a response.

The possibility of response, in turn, leads me to a different set of strategic possibilities: how might the dialogue between anthropology and natural science transform each?

## How is anthropology changing – and changing its scientific interlocutors?

Consider the perspective of a bacterium, requests Jens Seeberg. From the bacterium's point of view, interactions with bacteriophages and with antibacterial medicines have something in common. Medical programmes offer opportunities for resistance for bacteria as well as patients; anthropology requires attention to both kinds of resistance. Similarly, for Allan Young, biofilm is a multi-species social world informed by quorum-sensing. What kind of anthropology is this? Anthropologists, once focused on humans alone, now they have to stretch to imagine social life among non-human companions. The social will never be the same.

However, anthropologists generally have no microscopes, no DNA-based diagnostic tests. How are we supposed to learn anything about non-human sociality especially when it involves something as tiny as microbes? If we cannot come up with independent findings, just what are our contributions? One way forward begins with the posing of empirical questions; answerable questions that we might like our colleagues in the biosciences to explore. Good questions come from outside one's own field in any kind of scholarship; we respond to the urgent requests of social

movements, disasters, or big dreams. Ethnographic research on more-than-human sociality can raise questions that natural scientists might not have thought to ask, and can show their importance.

Julie Livingston's chapter offers just this kind of challenge. In the Botswana clinic where she studied, many cancer patients are also infected with HIV and tuberculosis. It changes the symptoms of each as well as their treatment options. It changes social status and thus how patients can be cared for. Description of individuals does important work here. It forces the heterogeneity of co-morbidity to the front of the research agenda. Our colleagues in the biosciences are asked to respond. Livingston's cases make it clear that we need more research on how co-infection and co-morbidity work, and we need this research to include considerations of social status. To begin the task of creating new interlocutors in the biosciences, we need such empirical challenges, which appeal to the curiosities of both scientists and humanists. Here is one way to continue beyond biodeterminism.

## What's ahead for 'bioindeterminism?'

By pointing us beyond 'biodeterminism', this volume suggests we might pile up tools for analysis of what one would have to call 'bioindeterminism', that is, the historically inflected and thus indeterminate courses of biological phenomena. In the study of indeterminacy, it is clear: we are participants and not just observers and critics. Anthropology refused the determinisms of the late nineteenth- and twentieth-century modernist creed; we are among those scholars best equipped to explore the indeterminate. We have insights to offer our natural science colleagues if we can figure out how to create research in common.

This means moving beyond humanist/scientist divisions of labour, such as those that ask anthropologists to study the ethics while scientists do the research. That kind of complementarity was built into twentieth-century modernism; it maintains conventional gaps rather than establishing common curiosities. To take 'indeterminism' seriously requires drawing social science and history *inside* biological research.

The 'local biologies' offered by Jörg Niewöhner and Margaret Lock are one kind of guide. If biology (both as knowledge and as interactions among living beings and components) is shaped in local scenes, indeterminism comes to the fore. In such cases, biologies are creatures of shifting material histories as much as conceptual ones. 'Race', for example, was made in the history of slavery not only because the concept was shaped

there but also because slavery informed marriage, property inheritance, and extra-marital sexuality, which in turn shaped racial genealogies and racial possibilities for health and wellbeing.

For the study of indeterminacy, anthropology has many great tools. These include history at multiple scales as well as attention to encounters, contingencies, and conjunctures. There are processes of 'translation', in all that word's meanings. There are articulations, multiple ontologies, botched communications, and the whole world of 'friction' in the sense of historical trajectories coming into being. There is much to explore in the terrain staked out but never fully controlled by modernist projects of science and medicine, including biodeterminism. Biodeterminism, indeed, has launched institutions that spawn new forms of indeterminacy; in those supposedly orderly playgrounds, bacteria, fast food, and ghosts, as well as humans, form their own unpredicted socialities.

This volume suggests the adventures still to be had in getting to know this terrain. Medical anthropologists have led the way in a process that shapes the wider field. It is not enough to observe from afar, they explain. We are also players in showing how biologies variously come to life. This volume illuminates that path.

## References

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# Index

*Biosocial Worlds* presents state-of-the-art contributions to anthropological reflections on the porous boundaries between human and non-human life – biosocial worlds. Based on changing understandings of biology and the social, it explores what it means to be human in these worlds. Growing separation of scientific disciplines for more than a century has maintained a separation of the 'natural' and the 'social' that has created a space for projections between the two. Such projections carry a directional causality and so constitute powerful means to establish discursive authority.

While arguing against the separation of the biological and the social in the study of human and non-human life, it remains important to unfold the consequences of their discursive separation. Based on examples from Botswana, Denmark, Mexico, the Netherlands, Uganda, the UK and USA, the volume explores what has been created in the space between 'the social' and 'the natural', with a view to rethink 'the biosocial'. Health topics in the book include diabetes, trauma, cancer, HIV, tuberculosis, prevention of neonatal disease and wider issues of epigenetics. Anthropological reflection and ethnographic case studies explore how 'health' and 'environment' are entangled in ways that move their relation beyond interdependence to one of inseparability. The subtitle of this volume captures these insights through the concept of 'health environment', seeking to move the engagement of anthropology and biology beyond deterministic projections.

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