

# Postcolonial Global Health, Post-Colony Microbes and Antimicrobial Resistance

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## Abstract

Rather than ‘superbugs’ signifying recalcitrant forms of life that withstand biomedical treatment, drug resistant infections emerge within and are intricate with the exercise of social and medical power. The distinction is important, as it provides a means to understand and critique current methods employed to confront the threat of widespread antimicrobial resistance. A global health regime that seeks to extend social and medical power, through technical and market integration, risks reproducing a form of triumphalism and exceptionalism that resistance itself should have us pause to question. An alternative approach, based on a postcolonial as well as a ‘post-colony’ approach to health and microbes, provides impetus to challenge the assumptions and norms of global health. It highlights the potential contribution that vernacular approaches to human and animal health can play in altering the milieu of resistance.

## Keywords

global health, materiality, postcolonial theory, resistance

Where there is power, there is resistance, and yet, or rather consequently, this resistance is never in a position of exteriority in relation to power. (Foucault, 1990: 95–6)

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## On Resistance

Resistance, whether understood as counter-repressive opposition to a dominant order or as agonistic process inherent to the exercise of power, is normally associated with intentional and emergent political acts (Hughes, 2019; Sharp et al., 2000; Foucault, 1990; Lilja and Vinthagen, 2018; Scott, 1985; Featherstone, 2008). This predominantly social reading of power and resistance has been under sustained challenge for some time. Foucault was of course insistent on the role of discursive practices, and the ‘disposition of things’ (Foucault, 2007: 99), within any process of governing. His mobilization of the term ‘milieu’ to mark an intersection of a multiplicity of individuals (or entities) ‘in a set of material elements that *act on* them and on which they act in turn’ (Foucault, 2007: 22, emphasis added) identified agential power as a more-than-human matter (see also Lemke, 2015: 10). The argument is well-made across the social sciences, from Feminist Science Studies (Haraway, 1985; Barad, 2007) to Philosophy (Stengers, 1997; Mol, 2002), Science and Technology Studies (STS) (Law, 1991; Latour, 1993), Geography (Braun and Whatmore, 2010), Anthropology (Kirksey and Helmreich, 2010) and Political Sciences (Bennett, 2010). To gloss things too briefly, ordering and resistance become a more or less agonistic dance of agency (Pickering, 2008), where systematic distinctions between human and other-than-human worlds continuously fail (Lemke, 2015).

This associational and other-than-human register is perhaps no more apparent than in the now frequent use of resistance to signal a swath of increasingly prevalent forms of untreatable infections and diseases. Drug resistant infections most often refer to the ability of pathogenic microbes and protozoa to bypass the pharmaceutical therapies that have been manufactured and used (often liberally) as a means to reduce their effectivity. Specifically, and while not a new phenomenon, the rise of antibiotic and antimicrobial resistance<sup>1</sup> has prompted increasing concern over the last few decades. Widespread drug resistance threatens to undermine health care practices and return societies, some argue, to a pre-modern age, or propel them into a post-antibiotic future (Davies, 2013; Brown and Nettleton, 2017).

This surfeit of microbial resistance is perhaps testimony to a form of material recalcitrance, or even ‘thing power’ (Bennett, 2010). Resistance here might figure as that which frustrates medical power – with recalcitrance a matter of microbiological steadfastness combined with inappropriate or ‘irrational’ medicine use. The figure of the oppositional ‘super bug’ coupled to the poorly disciplined clinical setting, unregulated pharmaceutical industry, weak infrastructure, and/or a rapacious and unruly food production sector are frequent *bêtes noires* in this tale of material mis-behaviour and mis-management (Laxminarayan et al., 2013; Podolsky, 2014; Santesmases, 2018; Nerlich and James, 2008).

Resistance is, in that sense, a matter to be overcome (with improved pharmaceuticals, greater awareness and behavioural change as means to manage the social-microbiological interface). Indeed, these mobilizations of resistance, which imply matters to be extrinsic to medical order, suggest a narrative of mastery and eventual control; there is a tone of 'we're not quite there yet' as innovation and improved governance seek to tame more and more of their social and material environs.

Another possibility, and perhaps more in keeping with the material politics that Foucault and others started to trace, is to refuse to see microbial resistance as extrinsic to any exercise of power. Rather, untreatable conditions are products of their milieu. Resistance is not a steadfastness, temporary or otherwise, in the face of the imposition of a norm, but part and parcel of a play of forces. In this vein, resistance is integral with social power, and can constitute an event that ushers in new possibilities, and new modes of normativity (Canguilhem, 1991 [1966]). It has a 'virtual power' which may give us pause for thought (Stengers, 2005: 185), and so provide an opportunity to think again about microbes, social being and normative categories of health and disease. In this register, there is a need to avoid a form of materialism or vitalism that too quickly abstracts living matters from their histories (Landecker, 2016; Latour, 1999) and geographies. As Braun and Whatmore (2010: xxix) suggest, contra vitalism, there is a need to pay close 'attention to the *specificity* of the matter at hand', its relationships and responses to exercises of power, rather than to invoke a generic analogy to 'life', liveliness or thing power. This may be more than a matter for conceptual clarity. For to invoke a metaphysics of matter also tends to imply a unified response to that matter, when the 'matter at hand', or the milieu of resistance, may provide some rather different lessons in terms of how best to respond.

In the terms of this paper, the question is, how can the socio-material milieu of drug resistant infections provide impetus to the current predicament? Specifically, and baldly, the paper argues that the tendency to treat drug resistance as material and social recalcitrance, and to assume that its very singularity provides the basis for a unified approach to the problem, irrespective of milieu, health practices or ecologies, risks reproducing a form of human exceptionalism that resistance itself should have us pause to question. In particular, the yoking of resistance to a current moment in global health results, I argue, in a peculiarly impoverished approach to resistance. In contrast, and as Foucault's knotty account of resistance has it, one is often 'dealing with mobile and transitory points of resistance, producing cleavages in a society that shift about, fracturing unities and effecting re-groupings [...] the swarm of points of resistance traverses social stratifications and individual unities. And it is doubtless the strategic codification of these points of resistance that makes a revolution possible' (Foucault, 1990: 96). To miss the swarm of points of

(antimicrobial) resistance, and to quickly invoke a unity, undermines the radical potential for a politics of more-than-human resistance.

In order to develop this argument, I take a number of slices through the resistance predicament. First, I trace the ways in which the issue has been formatted as an international issue. Second, I characterize its problematization as a particular instantiation of postcolonial global health, and third, I outline a brief history of ‘post-colony’ microbes. I finish with cases from health care and food production as a means to illustrate where a reanimated resistance politics, alive to social and microbial difference, might take us.

## **On Antimicrobial Resistance**

Antimicrobial resistance, or the ability of microbial life (including bacteria, viruses, archaea, fungi and protozoa) to persist in the presence of the medicines and other chemicals that have been developed and used to control them, is a global challenge with threats to universal health coverage and sustainable food supplies. In terms of impacts, drug resistant infections are, and will be, particularly devastating to already vulnerable populations, with people in low-income countries severely affected by increases in disease incidence, reduced food production and, in addition to current shortfalls in medicine availability, a lack of reliably effective treatments (Ahmed et al., 2018; Ardal et al., 2016). As the worldwide total of extremely poor people is predicted to treble by 2030 (a figure that is likely to be a gross underestimate after COVID-19), limited access to available and effective medicines will be even more serious in those communities which are already under severe socio-economic stress (Goutard et al., 2017; Roope et al., 2019; World Bank, 2017). Widespread drug resistance will also be life-limiting to those people who are immunocompromised and may render previously routine or minor medical conditions untreatable (Smith and Coast, 2013). Beyond human health, resistance will impact on food systems (Grace, 2015) and, combined with other security challenges, will undermine global and national resilience.

This crisis-in-the-making and emergency-to-come is commonly attributed to the mid-20th-century expansion of antimicrobial treatments (Landecker, 2016; Kirchhelle, 2020; Klein et al., 2018), as well as to the stalling of relevant research and development from the 1970s onwards (itself the result of market failures, mergers, acquisitions and privatizations, and slow bench-to-bedside processes) (Payne et al., 2007). Inappropriate and avoidable use of antibiotics and antimicrobial compounds as well as transmission of resistant organisms to and from people, livestock and the environment has altered somatic as well as environmental microbial selection processes and pressures (Wellington et al., 2013; Holmes et al., 2016; Bengtsson-Palme et al., 2018; Caudell

et al., 2018). The emergence, persistence and transmission of resistant strains of bacteria and mobile resistance-conferring genes over several decades are arguably key indicators of Anthropocene-era changes to planetary biology (Landecker, 2016; Gillings, 2017). As Landecker phrases it, ‘the bacteria of today are not the bacteria of yesterday [...] [having] different plasmids and traits and interrelations and capacities and distributions and temporalities than bacteria before modern antibiotics’ (Landecker, 2016: 21).

Similar in manner to the international policy-framings of climate change (Wynne, 2010; Yusoff and Gabrys, 2011; Lee and Motzkau, 2013), action on resistance is underpinned by a narrative of an unregulated past and a profligate present, both of which seed an apocalyptic future (Brown and Nettleton, 2017). In response, a dire prophecy is drawn into the present, with calls for immediate action to avert worst-case scenarios. The temporal and ‘balance sheet’ disjuncture between immediate benefits and deferred public costs partly explains the difficulties in generating collective action for the emergency-to-come. A dominant framing of the issue has focused on the problem of ‘irrational’ resource or medicine use, the need for greater public awareness of the consequences of that use and subsequent behavioural change. Improving prescription practices in health care settings through antibiotic stewardship schemes, and altering patient expectations and medicine use through public information and awareness campaigns, have become key objectives of international and national policy prescriptions (Charani and Holmes, 2019; Will, 2019). Within agriculture, which accounts for well over half of global antibiotic consumption (and a raft of other antimicrobial compound uses) (Van Boeckel et al., 2015), there has been a similar focus on reducing veterinary prescriptions of antibiotics and on educating farmers in the appropriate applications of antimicrobials and alternatives (Laxminarayan et al., 2013). This focus on awareness, behaviour change and choice (Shove, 2010) has attracted broad social science critique, neglecting as it does the social, cultural and material drivers of health and illness, the social and cultural meanings and practices that relate to medicines, and the economic margins and pressures that relate to health care provision and food production (Chandler et al., 2016; Hinchliffe et al., 2018; Broom et al., 2020).

In terms of its spatiality, drug resistance constitutes a global threat with a distinctly uneven distribution of causes, vulnerabilities and responsibilities. If the historical gestation of the issue had its focal point in the Global North, current concerns around growth in antimicrobial production, need and use focus on the Global South. While regulatory actions may be starting to generate positive signals in many higher income countries (though see Broom et al., 2020, on the limitations to stewardship), a concern is often expressed that relatively weak regulatory environments, poor surveillance, low levels of compliance, higher

microbial and disease burdens, insufficient medical or veterinary oversight and poor value chain governance make the resistance situation less tractable within lower and middle-income countries (Collignon et al., 2018; World Health Organisation, 2015). The current focus on lower income settings is partly driven by what Lakoff (2010) has labelled a global health regime of 'humanitarian biomedicine' but is also underpinned by a concern for 'global health security'. For the latter, the mobilizing logic is one of the emergence and global dissemination of resistant pathogens, genes and resistance-conferring mobile genetic elements. The transmission of New Delhi metallo-beta-lactamases from India to north-west Europe in the mid-2000s (Yong et al., 2009) and the widespread prevalence of mobile genetic elements associated with resistance to the last-line antibiotic Colistin (Liu et al., 2016) underpinned this security logic. As lower income settings became the focus for concern, so the familiar trope of modernization of backyard farms, backward clinics, scientific capacity and regulatory governance became key sites for consternation, investment and change (Braun, 2007; Shukin, 2009).

The focus on inappropriate behaviour, modern health and food infrastructure, as well as the figuring of an uneven though connected world of shared threats shaped a policy process wherein strategic international goals were agreed and then cascaded through a system of national action committees. In 2015, a Global Action Plan was endorsed at the 68th World Health Assembly, with signatories 'urged' to develop national action plans by 2017 (World Health Organisation, 2015). The global plan included five strategic objectives: to improve awareness and behaviour change; to develop surveillance of antimicrobial uses and resistance; to improve infection prevention and control; to optimize use of medicines; and to increase sustainable investment in combating resistance. Objective 1 of the global plan, for example, stipulated that action was required to 'promote behavioural change, through public communication programmes that target different audiences in human health, animal health and agricultural practices as well as consumers' (World Health Organisation, 2015: 8).

A manual for drafting national action plans followed, with multisectoral committees encouraged to develop an 'incremental approach that countries can adapt to the specific needs, circumstances and available resources of each individual country' (WHO et al., 2016: 1). These circumstances and differences were largely framed as deficits relative to the stewardship activities and surveillance capacities in the geographical core of Euro-American modern health and food production, with comparative insufficiency reinforced by the simultaneous provision of international and bi-lateral funds that could be used to address shortfalls in surveillant capacity. The ability to meet global objectives was judged as a matter of the *stage* at which a country finds itself: 'As Member States are at different *stages* in combating AMR, there is flexibility in activity



planning and target setting to meet both local requirements and global priorities' (WHO et al., 2016: 5, emphasis added). In the same paragraph, the link between stage and capacity was underlined: 'Countries differ in the availability of coordinating mechanisms, existing legislation, their laboratory capacity and data on the impact of AMR on society. The drivers such as use of antimicrobials and the systems and structures available to prevent and control the emergence and spread of AMR may also vary. The status of each of these factors will influence decisions in planning, target-setting and prioritisation' (WHO et al., 2016: 5).

While flexibility was to be welcomed, it was also the case that framing of in-country circumstances as comparative lack followed a developmentalist agenda (Escobar, 1995). The latter tends to reduce geographical difference (with all of the material and social-spatial relations of past and present imperialisms, colonialisms, the exigencies of corporate capital and extractive relations between core and periphery) to a league table of relative wealth and technical 'capacity'. Differences become matters of temporal delay rather than ongoing spatial production (Massey, 2005) with little or no consideration of the effects of uneven development and spatialized impoverishment (Smith, 2008). The roles of structural adjustment and marketization of public services and their impacts upon the kinds of health care provision, agricultural practices, public spending and ultimately the relationships between people, environments and microbes are all effaced. These might include substantial variations in health care priorities (for example relating to primary health care needs); pressing issues with antimicrobial medicine supply where access to rather than excesses of treatments are the key concerns; the varying roles of state and civil society organizations as agents in the formation and delivery of health and food-related projects; and alternative trajectories for food production that do not follow the models of agriculture in the Global North. As differences are reduced to matters of relative capacity, these and other alternative modes of being or practice, which may offer key insights in terms of structural drivers of resistance, as well openings on to other kinds of development, become notable through their absence. In short, there is an implicit assumption that cultural and economic differences are obstacles to rational or good behaviour. Culture is a label that tends to be used as a synonym for inappropriate or incorrect (non-scientific) knowledge, and or misinformed beliefs, habits and practices (Ledingham et al., 2019). Similarly, economy tends to be understood as signifying levels of underdevelopment in terms of human health care provision and backyard/backward or poorly organized food production systems. In turn, the possible advantages or affordances of health cultures and agricultures that are not easily aligned to the conveyor belt of one-dimensional development are rarely acknowledged.

The idea that differences, cultural and otherwise, may act as assets, opportunities or openings onto new ways of framing and approaching

drug resistance was not countenanced in these publications. This omission, one could argue, was a missed opportunity but also ran the risk of normalizing the very conditions that can act as drivers of antimicrobial uses and resistance. In order to develop these points, there is need, first, to situate antimicrobial resistance policy within a marketized and integrative approach to global health and, second, to introduce a process-based or post-colony approach to ‘resistant microbes’.

## On Postcolonial Global Health

In a landmark review of global health, Nicholas King underlined the semantic and material links between global health and ‘American anxieties about living in a globalised world’ (King, 2002: 764). Writing at a time marked by heightened fears of bio-terror as well as pathogens of pandemic potential, King summarized a shift in international and global health from a colonial concern with non-western beliefs and practices, or epistemic difference, to a postcolonial one of economic and ontological integration. Less concerned with indigenous medical beliefs, a civilizing mission, or colonial governance, the triumphal and exceptionalist narratives of scientific and technological superiority and economic expansionism were instead increasingly linked to provision of and trade in health technologies and services. So, for example, in a report entitled *America’s Vital Interest in Global Health: Protecting Our People, Enhancing Our Economy, and Advancing Our National Interests*, the links were made explicit: ‘America must engage in the fight for global health from its strongest basis: its pre-eminence in science and technology. US expertise in science and technology and its strength in biomedical, clinical, and health services research and development are the engine that has helped power many of the advances in human health and well-being of this century’ (Institute of Medicine, 1997: v–vi). For King, there was a consequent shift in the geopolitics and geographies of international health from a colonial tendency to establish sanitary micro-territories, or a home from home within colonial ‘outposts’, to a more diffuse, less territorial, *network* that facilitated the circulation of biomedical information and technique. The contained spaces of the micro-colony or disease-free cordon sanitaire were displaced by a utopian biomedical macro-colony wherein health became an opportunity for market expansion. This supplanting of containment by a network of health markets was driven by a new spatial horror: ‘not the horror of matter (or bodies) out of place, which presupposed the identification of a place for matter; instead, it is the horror of places no longer mattering, of a “third-worlding” at home’ (King, 2002: 773). In other words, a bio-communicable world became simultaneously a homeland security threat and a market opportunity within an emergent ‘disaster capitalism’ (Cooper, 2008). Data gathering and international partnerships became key modes of operation, with



disease control ‘achieved through worldwide consumption of biomedical technology’ (King, 2002: 776).

For King, this age of health-as-market-opportunity augured a shift from a concern with epistemological differences and knowledge diffusion to a focus on efficiently managing global circulations of medical (and agricultural) services and products in a ‘smooth terrain of global capitalist exchange’ (King, 2002: 779). Global health was thus made conditional upon an export model of embodied knowledges and products to farmyards and clinics across the world. The resulting absence of questions of culture and belief systems within global public health suggested ‘that the conflict between “Western” and “traditional” health systems is either over (with the former as victor), or is wholly irrelevant’ (King, 2002: 782), with battles over cultural difference now displaced by ‘disagreements over the relative place of stakeholders in global exchange networks’ (King, 2002: 779). If colonial health was a system of epistemological conversion, its postcolonial successor was a matter of ontological integration. ‘Local populations present obstacles not because of incommensurate belief systems or cultural differences, but because of incomplete integration into the modern projects of total surveillance and seamless exchange’ (King, 2002: 782).

This account of global health integration is useful, though it is worth noting that the ‘irrelevance’ of incommensurable health knowledges has turned out to be slightly wide of the mark. First, while knowledge may no longer be a key tool of empire, markets in biomedical products and clinical as well as technical approaches to health and agriculture nevertheless involve shifting economies, practices and cultures, and, in so doing, arguably produce new colonial spaces of the ill-equipped *and* the ill-informed. Perhaps as a mirror to Anderson and Adams’ ‘Marie Celeste’ version of colonial science (Anderson and Adams, 2008), whereby scientific and technological knowledge was exported without due recognition of the role of commerce as its key mode of dispersal, King’s account suggests that it is now commerce that stands centre stage, while knowledge and science become the empty vessels through which this smooth terrain is enacted. In this sense, the image of a friction-free export model of global health technique may be somewhat deceptive. Rather, global health continues to enframe and capture recipient countries within western norms (Brown and Bell, 2008). Second, the popularity of social media platforms, the rise of health mis-information (especially, but not only, concerning vaccination) (Vraga and Bode, 2020), the role of ‘fake’ or counterfeit medicines and fake-in-the-real hybrids (Kingori and Gerrets, 2019) as well as a policy-based tendency to prioritize awareness and behaviour change, mean that non-biomedically mainstream knowledge continues to be framed as a persistent problem for global health. Third, in the particular case of antimicrobial resistance, the dominant discourse has not simply been the need to sell

more product but also to regulate sales and medicine use. The result has been a simultaneous need to align markets as well as to change beliefs and raise biomedical awareness. So, contra King, knowledge and beliefs have retained their relevance to global health and continue to be treated as matters for correction. In this, the spaces of the ill-equipped are simultaneously populated by those considered to be ill-informed. But before returning to the implications of this formatting of antimicrobial resistance as a matter for networking of technique *and* beliefs, there is a need to engage with post-colony microbes.

### **On Postcolonial Microbes**

Colonies are equally prevalent in ecological and biological thinking as they are in imperial and economic imaginations. Within biology more generally the metaphor of the colony is firmly linked to hierarchical categorizations of organization (cell, organisms, social group, colony) and inextricably bound to a species-centred imagination wherein a self-identical grouping occupies a space-time (Taylor and Dewsbury, 2018). Within microbiology, a colony tends to refer to a visible mass of organisms that are derived from the same ‘mother’ cell. These colonies were key to the science of bacteriology, with the ability to isolate and culture a bacterium and to test a resulting clonal population’s susceptibility to various antimicrobial treatments a mainstay of drug development and resistance surveillance. Indeed, the derivation of minimum inhibition concentrations and standard breakpoint assays on plated cultures became key tools in the framing of what counts as resistant microbes. Koch’s postulates of a self-same population of bacterial ‘species’ underpinned a methodology of isolation, reproduction and vertical inheritance of traits (Gradmann, 2009). Bacteria were, as a result, effectively fixed in their identities, with any variance explained through random mutations and vertically inheritable traits.

Explanations of antimicrobial or more specifically antibiotic resistance were initially based on this methodologically-driven clonal model. At low or poorly calibrated doses it was assumed that antibiotics would select for those strains within a bacterial colony that had developed the necessary cell wall or other cellular equipment to reduce or negate the effects of the treatment. As historians of medicine emphasize, the assumed evolutionary mechanism, and the likelihood that sub-lethal doses would lead to selection for resistance, spurred clinical researchers to advise long and high dose rates, and the development and prescription of a range of antibiotics which, when used in combination or sequence, would guard against the re-colonization of a patient with resistant strains (Podolsky, 2014; Bud, 2007). In the US, this model underpinned a commercial and regulatory battle to develop, market and approve a range of antibiotics

and fixed dose combinations, and in turn prompted new norms for clinical evidence-making (Podolsky, 2014).

The scientific basis for this account of both resistance and its therapeutic significance was rooted in the modern synthesis of Darwinian evolution and Mendelian genetics. Yet the primacy of this model of resistance, based on an understanding of self-identical clonal colonies of bacteria, was itself under threat just as the modern synthesis had gained ascendancy. Biochemists like Marjorie Stephenson raised the question in 1934 that perhaps ‘bacteria may tentatively be regarded as biochemical experimenters’ (cited in O’Malley, 2018: 327), while later work in molecular biology, including within teams led by Tsutomu Watanabe, Joshua Lederberg and others, challenged assumptions concerning bacterial identity and asexual or clonal reproduction in bacterial populations (Lederberg, 2000; Furuya and Lowy, 2006). As Creager (2007) tells it, these debates over microbiological departures from the modern synthesis were framed within disciplinary- as well as Cold War-fuelled contests over Lamarckian adaptation and neo-Darwinian inheritance, the Lysenko affair and the unexplained rise of multiple drug resistance in single strains. Yet, from the 1950s onwards, there was a disciplinary, if not clinical or pharmaceutical, shift from the micro-colonies of plated, self-same ‘species’, related and organized through vertical inheritance of genes, to a networked, post-clonal imaginary of diverse communities where differences could be shared horizontally, often within as well as between different microbiological ‘species’. The work of Watanabe and colleagues had demonstrated, for example, that resistance could be conferred by ‘cytoplasmic resistance factors’ and disseminated through diverse bacterial populations without changes to the chromosome. This ‘infective hereditary’ (Watanabe, 1963) involved the mobilization of genetic material between and within bacterial populations. In some ways foreshadowing the development of the post-genomic era and systems biology (Guttinger and Dupré, 2016), and the approaches made possible through metagenomics, this post-colony approach involved a move away from ‘a focus on single organisms or monogenomic species’ (Guttinger and Dupré, 2016: np). In its place, resistance becomes a relational process, generated, persisting and transmitting within and between ‘species’ as a ‘communal resource’ (McFall-Ngai et al., 2013). Mobile genetic elements enable resistance to be shared widely and conserved within a microbiological community, a sharing that can offset inhibitory fitness costs and allow resistance to persist even without the necessity of continued selection pressure from the addition of antimicrobial treatments (Melnik et al., 2015; Chow et al., 2021).

This post-colony sensibility informed what Wright (2007) designated as a global ‘resistome’, a term used for the collection of all the antibiotic resistance genes (in pathogens as well as commensal microbes) that exist, and which could act as a reservoir of genes that may be expressed and

transmitted. For Wright, and later Gillings (2017), the resistome is ancient, provides stores of resistance capabilities and has undergone substantial recent historical change. The pan-global resistome arguably gives substance to the early 20th-century biogeographical precept, or Baas-Becking principle, that 'everything is everywhere, it's the environment that selects' (O'Malley, 2008). In other words, if Landecker (2016) used infectious hereditary to emphasize the biology of history, then post-colony microbes augment history and start to open up the importance of treating resistance as a matter of geography. Doing so starts to trace a socio-biome wherein resistance is not simply a matter of microbial recalcitrance or social misconduct, but the agentic dance of socio-environmental processes.

### **On Doing Resistance Otherwise**

At the outset of this paper I suggested that the tendency to treat drug resistance as material and social recalcitrance, and to assume that its very singularity provides the basis for a unified approach to the antimicrobial resistance problem, irrespective of milieu, health practices or ecologies, risks reproducing a form of human exceptionalism and triumphalism that resistance itself should have us pause to question. The issue has been framed as a global health problem, the solution to which is to emphasize commercial and scientific integration rather than confronting uneven spatial processes of modernization. I have also raised the troubling figure of the resistome to emphasize that resistance is more than recalcitrance; it is a networked play of social and microbiological processes that undermines any straightforward reduction to a single causal driver. The liveliness of micro-organisms is therefore not a metaphysical property but something that has evolved within a milieu of human attempts at mastery. Similarly, resistance and the resistome relate to but are not determined by antimicrobial consumption. And yet, as we have seen, the tendency in global and national action plans is for integration of health and food production systems as a means to modernize and monitor medicine uses. The targets of opportunity (Weber, 2005) are the spaces of the ill-equipped (and the ill-informed), with a narrative of western modernism, scientific and technical integration and smooth exchange as the means through which resistance will be tamed. That formulation, it should be noted, has tended to downplay the potentials of infective hereditary or the networked aspects of the resistome – the ecological milieu or play of microbial inter-activity that give resistance a situated quality. The result is that we may have ended up with the wrong networks (economic and technical integration) fighting the wrong kinds of network (Thacker, 2005).

The preoccupation of global antimicrobial resistance policy with surveillance and behavioural correction in order to combat resistance

reproduces a logic of global health security, and in so doing has pursued a model of socio-economic network extension, with modern farming techniques, health care behaviours and data surveillance, key elements of integration. This extensionist model tends to assume a smooth operating surface, paying little attention to spatial difference, the *intensities* and the accompanying norms and conditions that are involved in any power play (Allen, 2011, 2016). In this final section I want to draw together the postcolonial global health critique of the approach to resistance with a post-colony sensibility to resistance in order to sketch out how and in what ways the issue may ‘force thought’ and challenge rather than re-inscribe normative categories of modern practice. I do so through a few brief cases. The cases are drawn from the author’s own experience on projects and from discussion with colleagues. They are in that sense indicative rather than representative.

Sustainably enhancing food production in South and South East Asia faces a range of challenges (Goutard et al., 2017; Coker et al., 2011; Godfray et al., 2010). In addition to increased and increasingly complex demands from growing populations, competition for resources and land, and uneven trade relations, there are climate stresses and sizable disease burdens. As farmers attempt to enhance production in conditions where bacteria can thrive, lack of access to antimicrobial treatments or to alternatives can be devastating to plant and animal health and to livelihoods. Under the terms of national action plans, and conditioned by earlier attempts to control emerging diseases, the predominant approach to veterinary and livestock uses of antimicrobials has been to seek to modernize production, reduce disease burden and so stem growth in antimicrobial uses. Biosecurity is one of the key terms in this disease control narrative. Replacing backyard and small-scale farms with modernized livestock operations where disease and inputs can be controlled under veterinary supervision, or reducing the disease exposures of small farms, have become key aims of global ‘One Health’ agriculture (Hinchliffe, 2015). However, this paradigm of disease-free farming, based on integration and seamless economic exchange in accordance with phyto-sanitary regulations, can prove untenable and even contradictory in some settings. Within poultry farming for example, replacing small holder and backyard farms with industrialized biosecure indoor farms is not only socio-economically destructive (Hinchliffe and Bingham, 2008), ineffective and even sometimes counter-productive in terms of disease control (Wallace et al., 2015; Dixon, 2015); it may also be increasingly inappropriate under conditions of climate-related environmental stress. Cole and Desphande (2019) argue that farmers around Bangalore, India, have often been forced by water stress and crop disease out of arable production and into poultry meat production, and, with little expertise in animal husbandry, they tend to use antibiotics to manage an array of animal health problems for non-native breeds in

often crowded and non-biosecure farms. One solution to this disease burden is to encourage indoor biosecure production. However, the capital, carbon and running costs (including temperature control) are beyond the vast majority of producers, and those that adopt indoor farming methods can inadvertently increase animal stress and reduce health with inappropriately selected breeds suffering in poorly ventilated buildings. Modernization under increasing climate stress can in this case produce the conditions for poorer animal health outcomes and, as a result, increased pressure to utilize antibiotics.

In Bangladesh there is a similar problem with 'missing middle' farms (commercial farms that are partially integrated into global markets but who have not benefited from investments in biosecurity or disease controls) (Belton et al., 2018), and who are part of the 'invisible cohort' of farmers who nevertheless account for the majority of food production worldwide (Kakkar et al., 2018). Within the economically important shrimp aquaculture sector (second only to finished textile goods in terms of Bangladesh's export earnings) there are efforts to reduce disease burden by making disease-free seed available to farms. Farmers have tended, in the past, to manage their ponds through continual adjustment to monsoon rains and other environmental variations by introducing more stock or species as temperature and salinity conditions vary. Partly in response to disease and other threats, farmers have stocked a variety of species and, where possible, used the same *gher* (embanked field or pond) to grow paddy rice as well as develop aquaculture. The result of this polyculture was reasonably reliable productivity and regular income over an entire growing season, even if the method was far from being best practice in terms of biosecurity. The NGOs and hatcheries that were funded internationally to encourage farmers to utilize the disease-free shrimp seed (or larvae) encouraged farmers to stock only once in a production period and avoid stocking with a variety of species in order to reduce disease incursion and animal stress. The result was a reduction in disease incidence, but a simultaneous increase in the consequences or stakes of any disease event. Diseases that were once tolerated and adjusted for with additional stock or other crops now constituted a threat not just of diminished livelihood but outright loss. As the disease-free technology and attendant practices were adopted and as farmers relinquished their vernacular forms of livelihood insurance and adaptation to disease threats, their economic precarity, itself related to the salvage accumulation (Tsing, 2015) process that best describes the farmers' partial integration into global value chains, tended to increase rather than decrease. Moreover, as antibiotic uses were described by farmers as attempts to rescue vulnerable stock and seen as a desperate measure to save livelihoods, the result of adopting disease-free seed was paradoxically associated with a tendency to increase rather than reduce reliance on disease treatments (Hinchliffe et al., 2018).



An alternative strategy is to work with farmers who have managed to develop an agro-ecological and arguably more resilient approach to farming in the face of disease and other challenges. In this case, seeing the farmers' stocking and harvesting practices as potential assets on which to build, rather than as barriers to modern production, may offer more opportunities for doing things otherwise. Conversely, viewing incomplete economic and phyto-sanitary integration as the main problem can serve to extend the conditions of production that encourage greater reliance on antimicrobial treatments. In these cases, economic divergence rather than convergence may offer resources for rethinking resistance threats.

In human health settings, the focus on awareness and behaviour has re-booted concerns around misplaced understandings of health and disease (the spaces of the ill-informed). For example, in many parts of Asia, affective bodily registers of heat and inflammation drive treatment-seeking practices. In busy primary health care settings in rural China, treatments are directed towards bodily responses rather than to infecting pathogens, and antibiotics are popularly known as 'anti-inflammatory medicines' (Lambert et al., 2019). From a stewardship, 'rational use' or public awareness angle, this would seem to be a misconception and based upon biomedically unorthodox understanding. But as Lambert and colleagues insist, to disqualify this knowledge would be to miss the ways in which health and disease are always mediated through sensory experience. Discounting experiential aspects of health and illness not only pursues a familiar and ill-fated deficit model of public health but may also miss the opportunity to work with vernacular accounts of health and illness as potential springboards for doing things otherwise. If Chinese, and presumably all, medicine has always been 'syncretic' (Law and Lin, 2017), or a hybrid gathering of knowledges and their partial associations, then it may be that these collectives of bodies and knowledges offer cultural resources for other kinds of practice. Without adopting a romanticized sense of Traditional Chinese Medicine, and not to underplay current pressures to prescribe antibiotics within the Chinese health care and insurance systems, working with vernacular notions of health may nevertheless open up the possibility for re-configuring health and illness as environmental, social and personal and subject to alteration through a course of illness (Zhan, 2014). As was the case for the Bangladeshi farmers, it may be the mix of modernisms and health approaches, rather than their wholesale replacement, which offers more practical as well as creative approaches to doing resistance otherwise.

Finally, social and environmental drivers of resistance can be as, if not more, important than antimicrobial uses, especially where transmission of resistance to and from commensal as well as pathogenic bacteria is enhanced. In Bangladesh, shrimp farmers have modelled potential resistance drivers in their environment, and highlighted how shortage of

capital, river waters and hatchery bought seed can all increase resistance risks in their *gher* (Hinchliffe et al., 2018). Linking this work to those efforts to understand sub-inhibitory resistance mechanisms, or minimum selective concentrations, which can be up to 230 times lower than minimum inhibitory concentrations if the social and ecological conditions are right, would start to give communities more evidence on which to act (Chow et al., 2021). In northern Tanzania, the links between systems biology, epidemiology and cultural practices is starting to take shape. There, and specifically within pastoralist communities, transmission of resistant bacteria and resistant genes from livestock to people is related to drinking raw milk (Caudell et al., 2018). While reducing uses of the antibiotic oxytetracycline in drought and climate-stressed cattle may be a long-term aim, the lack of veterinary infrastructure and of available alternative treatments, as well as the possibility that resistance will persist beyond any reduction in treatment uses, means that the most effective intervention is likely to be reducing transmission between cattle and people. In pastoralist communities this requires working with households to identify key pathways and acceptable alterations to human-animal practices. A key issue identified by the participants and researchers was the drinking of untreated milk, and the need to find a means of pasteurizing the milk without boiling (the latter makes the milk less nutritious and, for the Maasai, unpalatable) (Caudell et al., 2019). It is these kinds of culturally and ecologically specific findings that are required to address resistance issues. 'In low-income and middle income countries, where communities collectively have an extraordinary diversity of socio-economic systems that blend western and traditional medical belief systems and that operate within varying regulatory and health-care environments' (Caudell et al., 2018: 490) it is essential to understand the range of proximate and distal drivers of resistance as well as work with the grain of cultural and socio-economic conditions. Utilizing key social science and cultural tools that include participatory processes and the co-creation of workable interventions will generate the most effective outcomes and minimize the effects of unintended outcomes.

## **Conclusions: Viva la Resistance**

In Foucault's methodological precautions regarding power, he called for an ascending rather than descending analysis of power. In other words, rather than start from the centre or the top of a hierarchy and deduce power by seeing how far down it goes, we should begin with power's 'infinitesimal mechanisms, which have their own history, their own trajectory, their own techniques and tactics, and then look at how these mechanisms of power, which have their solidity and, in a sense, their own technology, have been and are invested, colonized, used, inflected, transformed, displaced, extended, and so on by increasingly general

mechanisms and forms of overall domination' (Foucault, 2004: 30). I have tried to demonstrate how microbial resistance, itself a subject of historical and material struggles, has been and is being 'annexed by global phenomena' (2004: 31). In this telling, resistance, microbial and otherwise, is intrinsic with these mechanisms of power. In refusing a metaphysical account of microbial liveliness, there is an opening to uncouple this process of continuing annexation. The latter is performed through the extension and reach of networks of command and control that operate under the auspices of a global health matrix that invariably views social, technical as well as epistemological differences as barriers to change. Extending a global health network may in this case not only miss the affordances and assets that allow us to think and do resistance otherwise, but also risks intensifying the very relations that have fuelled the global resistome.

None of this is designed to under-estimate the importance of drug resistance, and '*viva la resistance*' is not meant as a proclamation of support for a process that is causing and will undoubtedly cause widespread suffering in the future. The affirmation of resistance is instead indicative that the post-colony, post-genomic microbe may be a signal to think again about the assumed norms of global health. The post-colonial model of seamless exchange targets the spaces of the ill-equipped and the ill-informed. It is a surveillant architecture that exports science and technology under the premise of commercial integration while under-valuing cultural and economic difference (and downplaying the roles of structural and other forms of inequality). New therapies, phyto-sanitary exclusion zones and biomedical norms are being annexed to antimicrobial resistance policy while economic and social vulnerabilities as well as alternative practices and beliefs around health and illness are side-lined. That resistance ushers in a counter norm, or is an event that should give pause for thought, requires staying faithful to that event (Stengers, 2011), and working to affirm the lessons that may accrue from it, even while we are faced with the spectre of innumerable dangers. *Vive la resistance* is then a staying faithful to the event that is the global resistome. Instead of the war that is anti-biosis, it is to suggest that alternative practices, and using cultural and social approaches to these forms of life, may be the ones that give peace a chance.

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## Note

1. Antimicrobial refers to all chemicals and medicines that can kill or inhibit microorganisms (viruses, bacteria, archaea, fungi and protozoa). Antibiotic is a more specific term used to refer to naturally occurring and synthetic medicines used to limit or kill bacteria.

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## References

- Ahmed, Syud Amer, Barış, Enis, Go, Delfin S., Lofgren, Hans, Osorio-Rodarte, Israel and Thierfelder, Karen (2018) Assessing the global poverty effects of antimicrobial resistance. *World Development* 111: 148–160. DOI: 10.1016/j.worlddev.2018.06.022.
- Allen, John (2011) Topological twists: Power’s shifting geographies. *Dialogues in Human Geography* 1(3): 283–298.
- Allen, John (2016) *Topologies of Power: Beyond Territory and Networks*. London: Routledge.
- Anderson, Warwick and Adams, Vincanne (2008) Pramoedya’s chickens: Postcolonial studies of technoscience. In: Hackett, E.J., Amsterdamska, O., Lynch, M. and Wajcman, J. (eds) *The Handbook of Science and Technology Studies*. Cambridge, MA: MIT Press, pp. 181–204.
- Årdal, Christine, Outtersson, Kevin, Hoffman, Steven J., Ghafur, Abdul, Sharland, Mike, et al. (2016) International cooperation to improve access to and sustain effectiveness of antimicrobials. *The Lancet* 387(10015): 296–307. DOI: 10.1016/S0140-6736(15)00470-5.
- Barad, Karen (2007) *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning*. Durham, NC: Duke University Press.
- Belton, Ben, Bush, Simon R. and Little, David C. (2018) Not just for the wealthy: Rethinking farmed fish consumption in the Global South. *Global Food Security* 16: 85–92. DOI: 10.1016/j.gfs.2017.10.005.
- Bengtsson-Palme, Johan, Kristiansson, Erik and Larsson, D.G. Joakim (2018) Environmental factors influencing the development and spread of antibiotic resistance. *FEMS Microbiology Reviews* 42(1): fux053. DOI: 10.1093/femsre/fux053.
- Bennett, Jane (2010) *Vibrant Matter: A Political Ecology of Things*. Durham, NC: Duke University Press.
- Braun, Bruce (2007) Biopolitics and the molecularization of life. *cultural geographies* 14: 6–28.
- Braun, Bruce and Whatmore, Sarah (2010) The stuff of politics: An introduction. In: Braun, Bruce and Whatmore, Sarah (eds) *Political Matter: Technoscience, Democracy, and Public Life*. Minneapolis: University of Minnesota Press, pp. ix–xl.
- Broom, Alex, Kenny, Katherine, Prainsack, Barbara and Broom, Jennifer (2020) Antimicrobial resistance as a problem of values? Views from three continents. *Critical Public Health*. DOI: 10.1080/09581596.2020.1725444.

- Brown, Nik and Nettleton, Sarah (2017) 'There is worse to come': The biopolitics of traumatism in antimicrobial resistance (AMR). *The Sociological Review* 65(3): 493–508. DOI: 10.1111/1467-954X.12446.
- Brown, Tim and Bell, Morag (2008) Imperial or postcolonial governance? Dissecting the genealogy of a global public health strategy. *Social Science and Medicine* 67(10): 1571–9. DOI: 10.1016/j.socscimed.2008.07.027.
- Bud, Robert (2007) *Penicillin: Triumph and Tragedy*. Oxford: Oxford University Press.
- Canguilhem, Georges (1991 [1966]) *The Normal and the Pathological*. New York: Zone Books.
- Caudell, Mark A., Charoonsophonsak, P. Victor, Miller, Annalise, Lyimo, Beatus, Subbiah, Murugan, et al. (2019) Narrative risk messages increase uptake and sharing of health interventions in a hard-to-reach population: A pilot study to promote milk safety among Maasai pastoralists in Tanzania. *Pastoralism* 9(1): 7. DOI: 10.1186/s13570-019-0142-z.
- Caudell, Mark A., Mair, Colette, Subbiah, Murugan, Matthews, Louise, Quinlan, Robert J., et al. (2018) Identification of risk factors associated with carriage of resistant *Escherichia coli* in three culturally diverse ethnic groups in Tanzania: A biological and socioeconomic analysis. *The Lancet Planetary Health* 2(11): e489–e497. DOI: 10.1016/S2542-5196(18)30225-0.
- Chandler, Clare, Hutchinson, Eleanor and Hutchison, Coll (2016) *Addressing Antimicrobial Resistance Through Social Theory: An Anthropologically Oriented Report*. Available at: <http://researchonline.lshtm.ac.uk/3400500/> (accessed 10 December 2020).
- Charani, Esmita and Holmes, Alison (2019) Antibiotic stewardship – twenty years in the making. *Antibiotics (Basel, Switzerland)* 8(1): 7. DOI: 10.3390/antibiotics8010007.
- Chow, Louise K.M., Ghaly, Timothy M. and Gillings, Michael R. (2021) A survey of sub-inhibitory concentrations of antibiotics in the environment. *Journal of Environmental Sciences* 99: 21–27. DOI: 10.1016/j.jes.2020.05.030.
- Coker, Richard J., Hunter, Benjamin M., Rudge, James W., Liverani, Marco and Hanvoravongchai, Piya (2011) Emerging infectious diseases in southeast Asia: Regional challenges to control. *The Lancet* 377(9765): 599–609. DOI: 10.1016/S0140-6736(10)62004-1.
- Cole, Jennifer and Desphande, Jayant (2019) Poultry farming, climate change, and drivers of antimicrobial resistance in India. *The Lancet Planetary Health* 3(12): e494–e495. DOI: 10.1016/S2542-5196(19)30236-0.
- Collignon, Peter, Beggs, John J., Walsh, Timothy R., Gandra, Sumanth and Laxminarayan, Ramanan (2018) Anthropological and socioeconomic factors contributing to global antimicrobial resistance: A univariate and multivariable analysis. *The Lancet Planetary Health* 2(9): e398–e405. DOI: 10.1016/S2542-5196(18)30186-4.
- Cooper, Melinda (2008) *Life as Surplus: Biotechnology and Capitalism in the Neoliberal Order*. Seattle: University of Washington Press.
- Creager, Angela N.H. (2007) Adaptation or selection? Old issues and new stakes in the postwar debates over bacterial drug resistance. *Studies in History and Philosophy of Science Part C: Studies in History and Philosophy of Biological and Biomedical Sciences* 38(1): 159–190. DOI: 10.1016/j.shpsc.2006.06.016.

- Davies, Sally C. (2013) *The Drugs Don't Work: A Global Threat*. London: Penguin.
- Dixon, Marion W. (2015) Biosecurity and the multiplication of crises in the Egyptian agri-food industry. *Geoforum* 61: 90–100.
- Escobar, Arturo (1995) *Encountering Development: The Making and Unmaking of the Third World*. Princeton: Princeton University Press.
- Featherstone, David (2008) *Resistance, Space and Political Identities: The Making of Counter-Global Networks*. Oxford: Wiley-Blackwell.
- Foucault, Michel (1990) *The History of Sexuality, Volume 1: An Introduction*. New York: Vintage.
- Foucault, Michel (2004) *Society Must Be Defended*. London: Penguin.
- Foucault, Michel (2007) *Security, Territory, Population: Lectures at the Collège de France 1977–78*. London: Palgrave Macmillan.
- Furuya, E. Yoko and Lowy, Franklin D. (2006) Antimicrobial-resistant bacteria in the community setting. *Nature Reviews Microbiology* 4(1): 36–45. DOI: 10.1038/nrmicro1325.
- Gillings, Michael R. (2017) Lateral gene transfer, bacterial genome evolution, and the Anthropocene. *Annual New York Academy of Sciences* 1389: 20–39.
- Godfray, H. Charles J., Beddington, John R., Crute, Ian R., Haddad, Lawrence, Lawrence, David, et al. (2010) Food security: The challenge of feeding 9 billion people. *Science* 327(5967): 812. DOI: 10.1126/science.1185383.
- Goutard, Flavie Luce, Bordier, Marion, Calba, Clémentine, Erlacher-Vindel, Elisabeth, Góchez, Delfy, et al. (2017) Antimicrobial policy interventions in food animal production in South East Asia. *BMJ* 358: j3544. DOI: 10.1136/bmj.j3544.
- Grace, Delia (2015) *Review of Evidence on Antimicrobial Resistance and Animal Agriculture in Developing Countries*. International Livestock Research Institute. DOI: 10.12774/eod\_cr.june2015.graced.
- Gradmann, Christoph (2009) *Laboratory Disease: Robert Koch's Medical Bacteriology*. Baltimore: Johns Hopkins University Press.
- Guttinger, Stephan and Dupré, John (2016) Genomics and postgenomics. In: Zalta, Edward N. (ed.) *The Stanford Encyclopedia of Philosophy (Winter 2016)*. Available at: <https://plato.stanford.edu/archives/win2016/entries/genomics/> (accessed 10 December 2020).
- Haraway, Donna (1985) Manifesto for cyborgs: Science, technology and socialist feminism in the 1980s. *Socialist Review* 80: 65–108.
- Hinchliffe, Steve (2015) More than one world, more than one health: Reconfiguring interspecies health. *Social Science and Medicine* 129: 28–35.
- Hinchliffe, Steve and Bingham, Nick (2008) Securing life – the emerging practices of biosecurity. *Environment and Planning A* 40: 1534–1551.
- Hinchliffe, Steve, Butcher, Andrea and Rahman, Muhammad Meezanur (2018) The AMR problem: Demanding economies, biological margins, and co-producing alternative strategies. *Palgrave Communications* 4(1): 142. DOI: 10.1057/s41599-018-0195-4.
- Holmes, Alison H., Moore, Luke S.P., Sundsfjord, Arnfinn, Steinbakk, Martin, Regmi, Sadie, et al. (2016) Understanding the mechanisms and drivers of antimicrobial resistance. *The Lancet* 387(10014): 176–187. DOI: 10.1016/S0140-6736(15)00473-0.



- Hughes, Sarah M. (2019) On resistance in human geography. *Progress in Human Geography*. DOI: 10.1177/0309132519879490.
- Institute of Medicine (1997) *America's Vital Interest in Global Health: Protecting Our People, Enhancing Our Economy, and Advancing Our International Interests*. Washington, DC: The National Academies Press. DOI: 10.17226/5717.
- Kakkar, Manish, Chatterjee, Pranab, Chauhan, A. Singh, Grace, Delia, Lindahl, Johanna, et al. (2018) Antimicrobial resistance in South East Asia: Time to ask the right questions. *Global Health Action* 11(1): 1483637.
- King, Nicholas B. (2002) Security, disease, commerce: Ideologies of postcolonial global health. *Social Studies of Science* 32(5–6): 763–789.
- Kingori, Patricia and Gerrets, René (2019) Why the pseudo matters to global health. *Critical Public Health* 29(4): 379–389. DOI: 10.1080/09581596.2019.1605155.
- Kirchhelle, Claas (2020) *Pyrrhic Progress: Antibiotics in Anglo-American Food Production (1949–2018)*. New Brunswick, NJ: Rutgers University Press.
- Kirksey, S. Eben and Helmreich, Stefan (2010) The emergence of multi-species ethnography. *Cultural Anthropology* 25(4): 545–576.
- Klein, Eili Y., Van Boeckel, Thomas P., Martinez, Elena M., Pant, Suraj, Gandra, Sumanth, et al. (2018) Global increase and geographic convergence in antibiotic consumption between 2000 and 2015. *Proceedings of the National Academy of Sciences* 115(15): E3463–E3470. DOI: 10.1073/pnas.1717295115.
- Lakoff, Andrew (2010) Two regimes of global health. *Humanity: An International Journal of Human Rights, Humanitarianism, and Development* 1(1): 59–79.
- Lambert, Helen, Chen, Meixuan and Cabral, Christie (2019) Antimicrobial resistance, inflammatory responses: A comparative analysis of pathogenicities, knowledge hybrids and the semantics of antibiotic use. *Palgrave Communications* 5(1): 85. DOI: 10.1057/s41599-019-0293-y.
- Landecker, Hannah (2016) Antibiotic resistance and the biology of history. *Body & Society* 22(4): 19–52. DOI: 10.1177/1357034X14561341.
- Latour, Bruno (1993) *We Have Never Been Modern*. Hemel Hempstead: Harvester Wheatsheaf.
- Latour, Bruno (1999) *Pandora's Hope: Essays on the Reality of Science Studies*. Cambridge, MA: Harvard University Press.
- Law, John (ed.) (1991) *A Sociology of Monsters*. London: Routledge.
- Law, John and Lin, Wen-yuan (2017) Provincializing STS: Postcoloniality, symmetry, and method. *East Asian Science, Technology and Society* 11(2): 211–227. DOI: 10.1215/18752160-3823859.
- Laxminarayan, Ramanan, Duse, Adriano, Wattal, Chand, Zaidi, Anita K.M., Wertheim, Heiman F.L., et al. (2013) Antibiotic resistance – the need for global solutions. *The Lancet Infectious Diseases* 13(12): 1057–1098. DOI: 10.1016/S1473-3099(13)70318-9.
- Lederberg, Joshua (2000) Infectious history. *Science* 288(5464): 287–293.
- Ledingham, Kate, Hinchliffe, Stephen, Jackson, Mark, Thomas, Felicity and Tomson, Goran (2019) *Antibiotic resistance: Using a cultural context of health approach to address a global health crisis*. Copenhagen. Available at: <http://www.euro.who.int/en/publications/abstracts/antibiotic-resistance->

- using-a-cultural-contexts-of-health-approach-to-address-a-global-health-challenge-2019 (accessed 10 December 2020).
- Lee, Nick and Motzkau, Joanna (2013) Varieties of biosocial imagination: Reframing responses to climate change and antibiotic resistance. *Science, Technology and Human Values* 38(4): 447–469.
- Lemke, Thomas (2015) New materialisms: Foucault and the ‘Government of Things’. *Theory, Culture & Society* 32(4): 3–25.
- Lilja, Mona and Vinthagen, Stellan (2018) Dispersed resistance: Unpacking the spectrum and properties of glaring and everyday resistance. *Journal of Political Power* 11(2): 211–229. DOI: 10.1080/2158379X.2018.1478642.
- Liu, Yi-Yun, Wang, Yang, Walsh, Timothy R., Yi, Ling-Xian, Zhang, Rong, et al. (2016) Emergence of plasmid-mediated colistin resistance mechanism MCR-1 in animals and human beings in China: A microbiological and molecular biological study. *The Lancet Infectious Diseases* 16(2): 161–168. DOI: 10.1016/S1473-3099(15)00424-7.
- Massey, Doreen (2005) *For Space*. London: Routledge.
- McFall-Ngai, Margaret, Hadfield, Michael G., Bosch, Thomas C.G., Carey, Hannah V., Domazet-Lošo, Tomislav, et al. (2013) Animals in a bacterial world, a new imperative for the life sciences. *Proceedings of the National Academy of Sciences of the United States of America* 110(9): 3229–3236. DOI: 10.1073/pnas.1218525110.
- Melnyk, Anita H., Wong, Alex and Kassen, Rees (2015) The fitness costs of antibiotic resistance mutations. *Evolutionary Applications* 8(3): 273–283. DOI: 10.1111/eva.12196.
- Mol, Annemarie (2002) *The Body Multiple: Ontology in Medical Practice*. Durham, NC: Duke University Press.
- Nerlich, Brigitte and James, Richard (2008) ‘The post-antibiotic apocalypse’ and the ‘war on superbugs’: Catastrophe discourse in microbiology, its rhetorical form and political function. *Public Understanding of Science* 18(5): 574–590. DOI: 10.1177/0963662507087974.
- O’Malley, Maureen A. (2008) ‘Everything is everywhere: But the environment selects’: Ubiquitous distribution and ecological determinism in microbial biogeography. *Studies in History and Philosophy of Science Part C: Studies in History and Philosophy of Biological and Biomedical Sciences* 39(3): 314–325. DOI: 10.1016/j.shpsc.2008.06.005.
- O’Malley, Maureen A. (2018) The experimental study of bacterial evolution and its implications for the modern synthesis of evolutionary biology. *Journal of the History of Biology* 51(2): 319–354. DOI: 10.1007/s10739-017-9493-8.
- Payne, David J., Gwynn, Michael N., Holmes, David J. and Pompliano, David L. (2007) Drugs for bad bugs: Confronting the challenges of antibacterial discovery. *Nature Reviews Drug Discovery* 6(1): 29–40. DOI: 10.1038/nrd2201.
- Pickering, Andrew (2008) New ontologies. In: Pickering, Andrew and Guzik, Keith (eds) *The Mangle in Practice: Science, Society and Becoming*. Durham, NC: Duke University Press.
- Podolsky, Scott H. (2014) *The Antibiotic Era: Reform, Resistance, and the Pursuit of a Rational Therapeutics*. Baltimore: Johns Hopkins University Press.

- Roope, Laurence S.J., Smith, Richard D., Pouwels, Koen B., Buchanan, James, Abel, Lucy, et al. (2019) The challenge of antimicrobial resistance: What economics can contribute. *Science* 364(6435): 4679. DOI: 10.1126/science.aau4679.
- Santesmases, María Jesús (2018) *The Circulation of Penicillin in Spain: Health, Wealth and Authority, Medicine and Biomedical Sciences in Modern History*. Basingstoke: Palgrave Macmillan.
- Scott, James C. (1985) *Weapons of the Weak: Everyday Forms of Peasant Resistance*. New Haven, CT: Yale University Press.
- Sharp, Jo, Routledge, Paul, Philo, Chris and Paddison, Ronan (eds) (2000) *Entanglements of Power: Geographies of Domination/Resistance*. London: Routledge.
- Shove, Elizabeth (2010) Beyond the ABC: Climate change policy and theories of social change. *Environment and Planning A* 42(6): 1273–1285.
- Shukin, Nicole (2009) *Animal Capital: Rendering Life in Biopolitical Times*. Minneapolis: University of Minnesota Press.
- Smith, Neil (2008) *Uneven Development: Nature, Capital and the Production of Space, 3rd ed.* Athens: University of Georgia Press.
- Smith, Richard and Coast, Joanna (2013) The true cost of antimicrobial resistance. *BMJ: British Medical Journal* 346: f1493. DOI: 10.1136/bmj.f1493.
- Stengers, Isabelle (1997) *Power and Invention: Situating Science*. Minneapolis: University of Minnesota Press.
- Stengers, Isabelle (2005) Introductory notes an ecology of practices. *Cultural Studies Review* 11(1): 183–196. Available at: <http://epress.lib.uts.edu.au/journals/index.php/csrj/article/view/3459/3597> (accessed 10 December 2020).
- Stengers, Isabelle (2011) *Another Science is Possible: A Plea for Slow Science*. Cambridge: Polity.
- Taylor, Cynthia and Dewsbury, Bryan M. (2018) On the problem and promise of metaphor use in science and science communication. *Journal of Microbiology & Biology Education* 19(1): 19.1.46. DOI: 10.1128/jmbe.v19i1.1538.
- Thacker, Eugene (2005) Living dead networks. *FibreCulture* 4. Available at: <http://four.fibreculturejournal.org/fcj-018-living-dead-networks/> (accessed 10 December 2020).
- Tsing, Anna Lowenhaupt (2015) *The Mushroom at the End of the World*. Princeton: Princeton University Press.
- Van Boeckel, Thomas P., Brower, Charles, Gilbert, Marius, Grenfell, Bryan T., Levin, Simon A., et al. (2015) Global trends in antimicrobial use in food animals. *Proceedings of the National Academy of Sciences* 112(18): 5649–5654. DOI: 10.1073/pnas.1503141112.
- Vraga, Emily K. and Bode, Leticia (2020) Defining misinformation and understanding its bounded nature: Using expertise and evidence for describing misinformation. *Political Communication* 37(1): 136–144. DOI: 10.1080/10584609.2020.1716500.
- Wallace, Robert G., Bergmann, Luke, Kock, Richard, Gilbert, Marius, Hogerwerf, Lenny, et al. (2015) The dawn of Structural One Health: A new science tracking disease emergence along circuits of capital. *Social Science & Medicine* 129: 68–77. DOI: 10.1016/j.socscimed.2014.09.047.
- Watanabe, Tsutomu (1963) Infective heredity of multiple drug resistance in bacteria. *Bacteriological Reviews* 27(1): 87–115.

- Weber, Samuel (2005) *Targets of Opportunity: On the Militarization of Thinking*. New York: Fordham University Press.
- Wellington, Elizabeth M.H., Boxall, A., Cross, P., Feil, E.W.H., Gaze, P., et al. (2013) The role of the natural environment in the emergence of antibiotic resistance in Gram-negative bacteria. *Lancet Infectious Diseases* 13: 155–165.
- WHO, FAO and OIE (2016) *Antimicrobial resistance: A manual for developing national action plans*. Available at: <https://www.who.int/antimicrobial-resistance/national-action-plans/manual/en/> (accessed 10 December 2020).
- Will, Catherine M. (2019) The problem and the productivity of ignorance: Public health campaigns on antibiotic stewardship. *The Sociological Review* 68(1): 55–76. DOI: 10.1177/0038026119887330.
- World Bank (2017) *Drug-Resistant Infections: A threat to our economic future*. Washington, DC: World Bank.
- World Health Organisation (2015) *Global Action Plan on AMR*. Geneva, Switzerland. Available at: <http://www.who.int/antimicrobial-resistance/publications/global-action-plan/en/> (accessed 10 December 2020).
- Wright, Gerard D. (2007) The antibiotic resistome: The nexus of chemical and genetic diversity. *Nature Reviews Microbiology* 5(3): 175–186. DOI: 10.1038/nrmicro1614.
- Wynne, Brian (2010) Strange weather, again: Climate science as political art. *Theory, Culture & Society* 27(2–3): 289–305.
- Yong, Dongeun, Toleman, Mark A., Giske, Christian G., Cho, Hyun S., Sundman, Kristina, et al. (2009) Characterization of a new Metallo- $\beta$ -lactamase gene, bla<sub>NDM-1</sub>, and a novel erythromycin esterase gene carried on a unique genetic structure in *Klebsiella pneumoniae* sequence type 14 from India. *Antimicrobial Agents and Chemotherapy* 53(12): 5046. DOI: 10.1128/AAC.00774-09.
- Yusoff, Kathryn and Gabrys, Jennifer (2011) Climate change and the imagination. *WIREs Climate Change* 2(4): 516–534. DOI: 10.1002/wcc.117.
- Zhan, Mei (2014) The empirical as conceptual: Transdisciplinary engagements with an ‘experiential medicine’. *Science, Technology, & Human Values* 39(2): 236–263. DOI: 10.1177/0162243913520045.

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