DOHaD Pasts, Presents, and Futures

An Introduction

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In the photograph on the cover of this book, we peer into the lives of three figures: two children and an adult caregiver. They are balanced at play on a seesaw in an urban park. Modernist hierarchies of distinction are rendered opaque here; it is not easy to discern any markers of gender, ethnicity, and class through which we might read the relationships between these figures and place them in a broader social order. Yet this absence perhaps amplifies the intimacy between the figures, sensed in the throbbing colours that weave them together. The image glows with intensity, and the figures seem to blur at their edges, spilling into one another and the environment of the playground.

This striking photograph was created with thermography, where a thermal camera captures an image using infrared waves rather than the light of traditional photography. Originally developed for military purposes, the technology was adapted here as part of a collaboration between photographer Nicholas Eppel and anthropologist Fiona Ross about the 'First 1000 Days', a health paradigm emphasising the developmental significance of the period from conception to age two. In the broader suite of photographs from which this cover image is drawn, Eppel and Ross sought new ways of depicting the social and biological relations that comprise development, autonomy, and caregiving. They sought, as they write, 'a way to open questions about how the "hard facts" of biology are given force and presence through "soft" actions of care' [1, p. 66].

The image resonates with a central concern of our book, which traces how the folded relations of sociality, interdependence, and biological life play out at one particular site: the field of the *Developmental Origins of Health and Disease* or DOHaD. DOHaD is one crucial body of research informing the First 1000 Days paradigm on which Eppel and Ross fix their gaze. The DOHaD field argues that environmental factors such as nutrition, stress, and toxic exposure shape health and well-being over extended periods of time [2]. DOHaD has had a far-reaching impact on understandings of how life experiences — and the social contexts in which they occur — become embodied, and how the effects of these embodiments are potentially passed on between generations. In this handbook, we consider the broad-ranging implications of the DOHaD hypothesis, the ways of seeing and thinking that have historically structured its uptake by diverse audiences and publics, and new conceptual apertures through which we might more effectively and equitably harness the insights of this field.

While focusing on health across the lifecourse, DOHaD has a strong focus on early life, where experiences during critical developmental windows – such as pregnancy, preconception, and from birth until age two – are seen as particularly impactful for future health across generations. Scientific research in this field has revolutionised

https://doi.org/10.1017/9781009201704.002 Published online by Cambridge University Press

understandings of pregnancy and health, highlighting the inseparability of fetal development from broader social contexts and material inequities, and the entanglement of a child and their caregivers. Yet in honing attention on pregnancy and early life, research has at times over-emphasised the maternal–fetal relation to a concerning degree, stripping it of context and obscuring the distributed relations through which pregnancy, birth, and child-rearing proceed.

A key reason we are drawn to Eppel's covering image is that it offers a perceptual reorientation of sorts in relation to the keystone figures of DOHaD analysis and the undue historical focus on the pregnant body. It offers us a compelling route for conceptualising intergenerational inheritance, in all its intimacy and vulnerability, without falling into the trap of reproductive sentimentality and highly gendered, heteronormative images of the mother–child dyad. While the figures depicted on the cover may well be a mother and children, it is not definitively apparent, and indeed, it is beside the point. What matters here is the evident intimacy between the three, regardless of biological or gestational ties; the pulses of heat depict an elemental kinship that is one crucial developmental environment, among others. When untethered from dominant gendered and racialising modes of perception in such a way, we might better account for the embodied intensities of care, the material environments through which we move, and the imprints we leave on the earthly surfaces that also imprint us.

This handbook grapples with these questions from the diverse perspectives of the authors assembled here, working in a wide range of fields in the life sciences, the social sciences, and the humanities. DOHaD is often described as an interdisciplinary scientific paradigm that incorporates multiple subdivisions within the life sciences and which social scientists and feminist scholars have subjected to critique. In this handbook, we define the field in more capacious terms, including scientists working with the DOHaD paradigm alongside social scientists and feminist scholars who have theorised DOHaD as an increasingly powerful discourse of health and inheritance. This editorial framing reflects our conviction that DOHaD as it is constituted today is not thinkable without the preceding decades of engagement from social theorists and feminists, who have indissolubly shaped the development of scientific research and its translation into policy and clinical care. Simultaneously, the history of scientific research in DOHaD has fundamentally reshaped critical social theories of embodiment, inheritance, and kinship, playing a fundamental role in the turn to the 'biosocial' in social theory, by providing insight into how social relations and inequalities literally shape biology at molecular scales [3, 4]. This handbook is a testament to the increasing collaboration between life and social scientists under the DOHaD banner, with DOHaD an exemplar of interdisciplinary collaboration.

In this introductory chapter, we set the scene for the rich contributions that follow by providing an overview of the field of DOHaD in a distinctly interdisciplinary tenor. We first trace the evolution of DOHaD over the past two decades, charting the historical conditions that have informed the emergence of this handbook. We then discuss the biosocial perspective that DOHaD offers as its central premise and promise, allowing for questions of socio-environmental justice and equity to be centred in science and biomedicine. Yet, as we explore, a range of obstacles complicate this biosocial agenda, requiring attention to questions of research translation, interdisciplinary lexicons, and genealogies of inequality.

Responding to the fundamental tension between a biosocial approach and its challenges, the handbook as a whole offers a comprehensive overview of contemporary

https://doi.org/10.1017/9781009201704.002 Published online by Cambridge University Press

biosocial collaborations in DOHaD. The handbook foregrounds a critical moment when the field is at a threshold of interdisciplinary innovation and maps future directions for research and collaboration. It serves as both an account of the field to date and a conceptual toolkit for future research, collecting histories, key concepts, and case studies of biosocial collaboration in action.

I.1 DOHaD: The Last 20 Years

Theories of DOHaD were developed in the late 1980s and 1990s through the convergence of epidemiological work investigating links between deprivation and later life disease, and experimental work in animals conducted by developmental physiologists (see Buklijas and Hanson in this volume). The DOHaD field was based on the hypothesis that environmental experiences can condition a developing organism in ways that heighten or lower the risk of disease in later life, a hypothesis with profound implications for health interventions and policy [5]. The field was formally established through the founding of the International DOHaD Society at the Second World Congress on Fetal Origins of Adult Disease in Brighton in 2003. In the subsequent two decades, the field has grown considerably, both in terms of research output and wider scientific and social recognition [5, 6]. During this time, DOHaD has developed institutionally, conceptually, and methodologically and is now a significant research agenda in health and well-being.

The change of the field's name from 'fetal origins of adult disease' to 'developmental origins of health and disease' in the early 2000s signalled a broadening of the research agenda. Early work in the field by David Barker and others had a strong focus on the prenatal period, linking nutritional restrictions in utero to later-life cardiovascular disease [7]. This focus has since expanded to consider how developmental factors influence health and disease over the entire lifespan, beginning in the so-called 'pre-conception' period before a child is conceived and continuing into advanced age [2, 6]. The field has also expanded in terms of the factors, conditions, and end points considered. While originally focussed on nutrition and metabolic disease, the fields of toxicology and psychiatry have widened the scope to include the study of teratogens and stress [8, 9]. In recent years, DOHaD research has also investigated the developmental origins of human well-being more broadly, including in topics such as adolescent cognitive function and educational attainment [10, 11].

Over the past two decades, the conceptual aperture for understanding 'development' in DOHaD has also shifted from a focus on pathological processes to a wider enquiry into normal development. Hanson and Gluckman [12] have argued that developmental effects are the result of physiological processes of developmental plasticity that have adaptive purposes insofar as they help the developing organism adapt to prospective environments, thereby linking DOHaD to current thinking in evolutionary biology. Similarly, the reversibility of developmental effects is increasingly discussed in DOHaD. Whereas early DOHaD thinking tended to view developmental effects as deterministic and permanent, as reflected in the language of 'developmental programming' (for a critique of the term, see 12), current DOHaD thinking increasingly eschews environmental determinism by attending to how the effects of early life adversity might be reversed in later life (Lloyd et al. in this volume).

The move towards a non-deterministic and non-pathological vision of development in DOHaD is inseparable from the interdisciplinary expansion of the field. Having

https://doi.org/10.1017/9781009201704.002 Published online by Cambridge University Press

emerged from the confluence of fetal physiology and epidemiology, DOHaD has been interdisciplinary from the outset (Buklijas and Hanson in this volume). Over time, it has coalesced diverse disciplinary approaches, including molecular biology, public health, data studies, different clinical specialties, and evolutionary biology, as well as economics, the social sciences, and humanities. At this stage, these interdisciplinary modes of knowledge-making typically occur across departments rather than in dedicated research centres, with only a few dedicated DOHaD research departments around the world [6].

A major site for the interdisciplinary expansion of DOHaD is recent advances in environmental epigenetics, a field that offers an explanatory model for the underlying mechanism of DOHaD observations [3, 13]. Environmental epigenetics studies how environmental factors influence the way genetic information – encoded in DNA – is transcribed and translated into biological processes, potentially influencing development, health, and disease. The first foundational studies in environmental epigenetics [14–16] in the early 2000s were quickly taken up in DOHaD. Buklijas and Hanson (in this volume) argue that the DOHaD field was, for a variety of reasons, originally uninterested in genomics; however, broader trends in science funding, such as the move towards funding genomic science and away from other areas like experimental physiology, are likely one key reason for the field's embrace of epigenomics in the mid-2000s. Both environmental epigenetics and DOHaD have profited from the links between the two fields [17]. In its early days, the fetal origins hypothesis was critiqued due to the absence of a clear mechanism; the entry of epigenetics has offered a 'molecular proof' of sorts. Concurrently, environmental epigenetics researchers have framed the medical and policy relevance of their work with reference to the DOHaD hypothesis [17].

The credibility tied to having a plausible mechanism in epigenetics may have contributed, among other factors, to the growing policy traction of the field since the mid-2000s. In 2010, the then-named DOHaD council launched the *Journal of DOHaD* to congregate the 'integrative, interdisciplinary, and translational' [18, p. 1] work of the field. Mark Hanson, then President of the DOHaD Society, wrote that the field had garnered sufficient acceptance in biomedical research, policy, and development agendas as to legitimate the journal's launch. Indeed, DOHaD has enjoyed significant traction in the last decades, especially in a global health context, which is increasingly concerned with the growing burden of non-communicable diseases (NCDs) in low- and middle-income countries [19]. There are regional DOHaD Societies that span six continents, including DOHaD Africa, DOHaD Society of Australia and New Zealand, DOHaD Latin America, US DOHaD, DOHaD Canada, DOHaD Japan, DOHaD China, the Pakistan DOHaD Society, and the French-Speaking DOHaD Society. International organisations such as the World Health Organization (WHO) and the World Bank have also integrated DOHaD frameworks into their agendas, as seen in the WHO's Childhood Obesity Report and the Bank's increasing investment in early childhood and maternal care [20].

At the same time, there is also a widespread feeling among DOHaD scientists that the field has not yet realised its full policy potential. In a recent editorial, former and current DOHaD society presidents Peter Gluckman, Mark Hanson, and Lucilla Poston have argued that the field has not yet found its footing in national and international health policy arenas [21]. They attribute this to DOHaD's emphasis on long-term effects in contrast to policy interest in short-term gains; a lack of coherent framing that presents a simple moral or ethical message; and the complexity of pathways within DOHaD that make it less amenable to identifying discrete points of effective intervention.

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Another possible reason for the limited uptake of DOHaD in health and social policy is that the field is open to contestation both for its central hypothesis and for its policy relevance [22]. Part of this is the experimental complexity of investigating how diverse factors influence health and disease over time [23]. While evidence for long-term developmental effects has been demonstrated in animal models [24], such evidence is much more difficult to obtain in human populations. Epidemiological cohort studies, the go-to method in DOHaD research, are prone to confounding effects and are ill-equipped to prove causal effects, limiting the translatability of the evidence base (though recent methodological advances in regard to Mendelian randomisation are promising in this regard) [25].

To expand the evidence base for DOHaD, scientists have turned to intervention studies or clinical trials. However, the results of interventions during pregnancy thus far have been disappointing [26]. In pregnancy trials drawing on DOHaD that focus on obesity, for example, to date no cohort studies have established conclusively that lifestyle interventions have a positive impact on obesity across the lifecourse [27]. Meanwhile, social and feminist theorists have cautioned that intervention studies can reinforce gendered and racialised assumptions about normative development, health, and parenting that maintain unjust racial hierarchies and centre the mother–child dyad to the detriment of broader socio-environments [27].

An additional methodological critique is that existing intervention studies have been limited (only targeting a limited set of factors) and constrained (only for a set time period). Currently, there is hope within the field that complex intervention studies like the HeLTI trial, which are interdisciplinary in nature and incorporate a critical, feminist understanding of social factors, will provide a sought-after evidence base that may better inform health policy and improved healthcare (see Pentecost et al. in this volume). These complex intervention studies try to account for the complexities of the biosocial processes in which they seek to intervene. Against the background of the COVID-19 pandemic, which exacerbated global inequalities in health, DOHaD researchers have also argued for the importance of considering developmental origins to promote social resilience and health equity [28].

In 2024, then, DOHaD is on a threshold. The field has expanded disciplinarily and conceptually. It has formulated an ambitious research programme in its quest to account for the complexity of how socio-environmental factors influence health and disease across the lifecourse, and studies have moved from observation to intervention to generate evidence with policy traction. Interdisciplinary DOHaD research promises to improve our understanding of how we can contribute to social and health equity. And it promises a deeper understanding of how social environments and biological processes intertwine to produce health and disease on both individual and population scales. It is this promise to which we now turn.

I.2 Promises of the Biosocial

The promise of DOHaD lies in large part in its biosocial understanding of health and well-being. That is, it offers tools to articulate — in both biological and social terms — the intergenerational mechanisms of health inequality. Through a DOHaD prism, social contexts and unequal living conditions are understood as directly impacting biological outcomes across generations, thus construing social contexts as having biological effects,

https://doi.org/10.1017/9781009201704.002 Published online by Cambridge University Press

and vice versa. As a result, DOHaD has opened new avenues for conceptualising the biological and the social as entangled and inextricable.

The biosocial is a conceptual frame and heuristic that seeks to bridge the divide between biology, typically seen as the remit of the life sciences, and the social and the cultural, traditionally the remit of the social sciences and humanities. In their 2018 introduction to the *Handbook of Biology and Society,* Maurizio Meloni and co-authors characterise the biosocial as an emerging research horizon defined by interdisciplinary convergences and a shift in proper objects of research and modes of knowledge production [4]. As they write, 'the life sciences, broadly conceived, are currently moving toward a more social view of biological processes, just as the social sciences are beginning to reincorporate notions of the biological body into their investigations' [4, p. 2]. Biology is revealed as thoroughly social, while social theory turns to biological data and methods as a lively site for understanding social relations. This is not simply attention to the socially constructed nature of scientific knowledge, although literature in this vein is a vital precursor to biosocial thinking [29–31]. Rather, a biosocial approach, as we understand it here, construes the biological and the social as inseparable domains that are always already co-constituted.

As a framework for thinking about biological development, the biosocial gathered momentum in social science literature in the early and mid-2000s. The idea of the 'biosocial' has been expressed in a range of ways by social theorists, who have introduced concepts like 'biocultural' [32], 'biosocial becomings' [33], 'embedded bodies' [34], 'impressionable biologies' [35], 'situated biologies' [36], and 'exposed biologies' [37], to highlight how biology is always processual and culturally embedded. These concepts build on vital scholarly antecedents that sought to bridge the divide between nature and culture. Most notable in this respect is Donna Haraway's feminist theorisation of 'naturecultures' [38]; Bruno Latour's elaboration of nature–culture hybrids [39]; and Paul Rabinow's work on 'biosociality', which challenged the silo-ing of biology and society implicit in the then emergent paradigm of 'sociobiology' [40].

This biosocial momentum emerged concurrently with a postgenomic turn in the sciences, characterised by greater attention to the relationships between genes and environments and an increasing awareness that the development of an organism cannot be separated from its milieu [35]. The past two decades have seen a shift in attention in the life sciences, from a focus on the 'blueprint' of DNA as exemplified by the Human Genome Project completed in 2003 to a greater examination of the role of context in biological processes in fields like epigenetics, microbiomics, and immunology [4]. These varied approaches conceptualise the body as open-ended and embedded in various environments that shape and reshape collective embodiment across generations [3, 35].

While findings in epigenetics boosted the public profile of DOHaD in recent decades, it may have come at the cost of DOHaD's earlier attention to the relationship between health outcomes and social contexts via pathways unrelated to genomics. In their foundational work from the late-1980s developing the fetal origins hypothesis, for example, David Barker and colleagues foregrounded structural factors, emphasising 'geographical and socio-economic constraints on the health of women and children' [41, p. 455] as paramount in shaping disparate susceptibility to chronic disease and mortality rates. As feminist scholars have cautioned, this early attention to social contexts and structural inequalities has since given way to a narrowed view of pregnant bodies and individualised lifestyle choices, with health and disease 'telescoped into a bodily environment of the womb' ([41, p. 458]; see also [6, 27, 42]).

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Many researchers have nonetheless welcomed DOHaD as an important field for critiquing the silo-ing of biology and society and reconceptualising health and disease in biosocial terms. Feminist accounts have drawn on DOHaD and allied postgenomic sciences to challenge the cultural iconicity of the mother–fetus dyad as the primary locus of reproduction and inheritance [43], pointing to how DOHaD enables an understanding of the 'reproductive environment' as situated in broader socio-environmental contexts [27, 44]. The liveliness of gestational and developmental biology is one capacious place from which to critique discourses that emphasise maternal responsibility and fetal personhood and to instead elaborate more complex models of human development [27, 43, 45]. As van Wichelen and Keaney write in their introduction to a recent special issue on *The Reproductive Bodies of Postgenomics,* 'postgenomics offers new models and conceptual horizons for understanding how we are materially related to one another beyond the fictive confines of the nuclear biogenetic family' [43, p. 1113]. This feminist mode of biosocial theorising is central to this handbook (see, for instance, chapters by Moore and Warin and by Karpin), as is the interdisciplinary concern with DOHaD's potential for securing health justice.

Another related site of biosocial thinking in DOHaD is changing understandings of categories of difference, such as race, class, and geographic location, and the material inequalities that accompany them. DOHaD analyses have generated new understandings of racialisation as a biosocial process (as explored in the chapters by Meloni et al. and Valdez and Lappé in particular). Social categories of race shape differential access to things like nutritious food, housing stability, protection from environmental toxins, and access to education and healthcare; as DOHaD research has illustrated, these factors directly shape unequal susceptibility to chronic disease, chronic stress, and mortality across generations, with disadvantaged and historically marginalised communities particularly affected [28, 46, 47]. A DOHaD approach confirms that racist social environments are exposures that become biological outcomes over time – or, as Clarence Gravlee put it, race *'becomes* biology' [48, p. 47]. As Shannon Sullivan argues, the racial health disparities often studied in health research are better conceptualised as '*racist* disparities' due to the way that social categories of race are not predetermined, but are rather biosocially materialised over time [49, p. 193].

Biosocial frameworks in DOHaD also offer new articulations of health justice. As Penkler and colleagues write, 'based on its key assumptions – that life circumstances, health, and disease are closely linked on a molecular scale – DOHaD is an inherently political research field' [6, p. 268]. DOHaD research is increasingly mobilised as a useful evidence base for attesting to the embodied intergenerational impacts of what are typically considered social or historical harms, including the processes and policies of dispossession associated with colonisation and slavery (see Keaney et al. in this volume and [50]). For example, Black and Indigenous communities are increasingly deploying epigenetic research to advocate for state reparations [51]. DOHaD and epigenetic insights hold the potential for creating more effective health and social policy responses to inequality by shifting the focus away from individuals and towards social contexts, which are in turn understood as impacting developmental outcomes. A biosocial frame may also resonate with Indigenous understandings of health and well-being and non-Western worldviews that regard personhood as inextricable from surrounding environments ([51]; see also Meloni and Rooney, and Bourke and Lovett in this volume).

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In a range of ways, the enthusiasm surrounding DOHaD hinges on its biosocial model of bodies and inheritance. And yet, despite the great promise of such a way of thinking, many challenges remain. Chief among them is the disentangling and re-siloing of the biological and the social when it comes to how scientific research is conducted in practice and translated into policy.

I.3 Challenges of the Biosocial

Radically interdisciplinary research in DOHaD is necessary to fulfil the potential of biosocial thinking. While the field is uniquely placed to produce innovative modes of collaboration, in part because of its deeply interdisciplinary history, it is vital to account for the challenges of a biosocial approach in practice.

Several scholars have highlighted the difficulties of representing biosocial complexity within traditional research models and methods, despite good faith efforts and clear frustrations [23, 52, 53]. For instance, DOHaD research often reduces 'the environment' to single, fixed variables – such as food (measured as calories), pollution exposures (often singular toxicants), and stress (measured by cortisol levels). From the pressures to present research in a more linear fashion, to producing publications quickly, to using cost-effective research methods, DOHaD research is embedded within institutional structures that compel scientists to make pragmatic choices around variables and proxies. Penkler [23] points in this respect to Knorr-Cetina's description of the 'decision-ladenness' [31] of research: decisions regarding variables and measures must be made among multiple, competing interests (costs, feasibility, and reliability) but also considerations such as the burden on participants and retention rates, and all this often across multiple contexts. Together, these factors can steer scientific research in reductionist directions.

While the use of single and fixed variables as environmental proxies is often a pragmatic necessity in scientific research, it has the effect of neglecting the complex histories and social relations that shape developmental environments (see Rossmann and Samaras in this volume). For instance, pinpointing a deficient diet among pregnant women may offer an experimentally feasible research question; however, it comes at the risk of backgrounding the more complex question of *why* certain populations face nutritional challenges. By defining the problem as one of individual behaviours, such research justifies interventions that also target individual choices. This renders interventions potentially futile, as these 'choices' remain deeply shaped by access and acceptability. It also potentially reproduces injustice by reinforcing gendered, classed, and racist patterns of responsibilisation and blame, siphoning the structural forces of racism, sexism, and poverty into a problem of individual behaviours [3, 6, 27]. While all research involves decisions that delineate a research object by focusing on certain aspects of the world at the expense of others [29, 31], it is crucial to be self-reflexive about and accountable for the kinds of decision we make as researchers, the histories of thought from which they emerge as sensible or even automatic, and the relations and futures that they preclude.

Working across disciplines may provide an opportunity to reflect on the decisions that delineate a research problem. Interdisciplinary teams could provide 'ethical safeguards' [54] against some of the critiques levelled at DOHaD research, such as its continuing focus on individual factors and behaviours. This individual focus dovetails

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with existing and historical assumptions about who and what is in need of intervention – what Pentecost terms DOHaD geographies [55]. The challenges here are multiple. Scientific research needs to reframe studies away from individual behaviours and mother-blaming [56, 57]. It also needs to remain attentive to the ways that research messaging overlaps with local histories and can reproduce stigmatising narratives (see Kenney and Müller in this volume). When brought into policy or public health messaging, DOHaD research needs to be adapted and reworked to fit within the needs of local communities (see Tu'akoi and colleagues in this volume).

The methodological and translational challenges facing biosocial research are heightened by the structural features of the contemporary university, often characterised by silo-ed disciplinary boundaries and employment structures. As with all academic knowledge creation, DOHaD research unfolds within the confines of institutional practices, knowledge and funding economies, and epistemic environments that can hinder fruitful biosocial collaboration. In the current context, quantitative data and the 'hard sciences' garner greater legitimacy and credibility than the social sciences and humanities [52]. This is particularly true in health research where implicit epistemic hierarchies result in the accommodation of social science approaches in biomedicine, rather than their full integration [58]. This problem is reflected in research funding culture [59], peer review [60], pedagogy [61], and academic recognition [58]. As a result, projects may only accommodate the 'addition' of social components and social scientists to biological and biomedical research teams, when the research problem has already been defined by scientists. Barry and Born [62] describe this kind of interdisciplinarity as the 'subordination-service model'. Such an arrangement perpetuates the bracketing of the 'social' from the 'biological' and offers little space for iterative learning from 'the social' in crafting and orienting future research. In thinking about the efficacy of biosocial collaboration, it is also important to extend the notion of collaboration beyond the academy to foster collaborative knowledge-making practices with the communities that DOHaD researchers recruit and study (see Tu'akoi and colleagues in this volume). Collaborative research may challenge the fundamental assumptions of biomedicine: for example the primacy of the individual versus Indigenous notions of collective personhood. At the same time, iterative, engaged, and interactive work with communities can be time-consuming and expensive and is thus often in tension with the demands of the neoliberal university. Addressing this tension requires commitment to the longer-term reshaping of research infrastructures.

I.4 Overview of Contributions

In this handbook, a global authorship has come together to reflect on the state of DOHaD today and the questions, tools, and ways of working that will foster the promise of a DOHaD research agenda that promotes health justice. The handbook is the product of our authors' patience with conversations not only across time zones but also across the divisions of disciplinary practice, language, and convention. Across 29 chapters, anthropologists, psychologists, physiologists, gender studies scholars, molecular biologists, clinicians, sociologists, epidemiologists, science and technology studies scholars, and legal scholars have worked towards interdisciplinary legibility as a foundation for generous exchange.

Many of the contributions are themselves the outcome of interdisciplinary engagements; some are explicitly framed as such, while others foreground a healthy scepticism

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for the interdisciplinarity DOHaD scholarship might meaningfully achieve. Defining interdisciplinarity is itself a fraught question: as Callard and Fitzgerald suggest, it is a term that 'everyone invokes and none understands' [63, p. 4]. The formalisation of 'interdisciplinarity' as a policy concern, academic orientation, and epistemic field has come with its own foreclosures, even as it has held the promise of openings [62, 63]. Yet in fields such as DOHaD, the need for collaborative research practices is irrefutable. We perceive a unique willingness in the DOHaD community to embrace an interdisciplinarity that allows for 'the co-existence of difference', to borrow from science and technology studies scholars Annemarie Mol and Anita Hardon, where 'solutions are sought that aim to do justice to each interlocutor's particular intellectual and practical stakes' [64, p. 4]. This is perhaps facilitated by the contributors' shared interest in intergenerational health, the folding of social inequality into bodies, what it means to live well, and how health interventions can aid this pursuit.

In six sections, the 29 chapters comprising this handbook represent the key debates, concepts, and case studies of interdisciplinary work in DOHaD. Section 1 traces the history of the field and its intellectual precursors. Maurizio Meloni and Natasha Rooney show in their contribution how thinking about 'maternal impressions', that is the idea that maternal experiences and emotions can leave long-lasting effects on the developing organism, has been a recurrent theme in different historical and cultural contexts since antiquity. Tatjana Buklijas traces how this idea has developed in the twentieth century, showing that conceptualisations of the maternal–fetal relationship have undergone marked change during this period. These changes, which are more complex than often assumed in standard historical accounts, are central to the story of DOHaD's emergence as a distinct field in the 'long decade' from 1989 to 2003. Mark Hanson and Tatjana Buklijas' chapter covers these 'first 5000 days' in which DOHaD was established as a distinct biomedical research field, beginning with an influential interdisciplinary meeting in 1989 between epidemiologists, led by David Barker, and fetal physiologists, and ending with the formation of the International DOHaD Society in 2003.

Section 2 is concerned with the social life of DOHaD research, and its interface with questions of injustice. Maurizio Meloni, Christopher Kuzawa, Ayuba Issaka, and Tessa Moll warn that deterministic notions of environment and development mobilised in DOHaD can reproduce an essentialist understanding of racial categories. Moore and Warin show how an overt focus on women's nutrition obscures the broad scope and implications of DOHaD for understanding health inequalities. Natali Valdez and Martine Lappé contend that gender and race are inseparably intertwined as social categories, arguing that a gendered and racialised health discourse disproportionally places the burden of intergenerational health on women of colour. Jennifer Cohen reviews economic research in DOHaD, arguing that it has often been limited by a narrow focus on molecular aspects and a decontextualised use of demographic variables, with the effect of obscuring social structures. Luca Chiapperino, Cindy Gerber, Francesco Panese, and Umberto Simeoni continue the critique of DOHaD's focus on the individual, describing this tendency as a 'moral paradox' characterising how health interventions are generated in the field. Finally, Isabel Karpin highlights the significant implications of DOHaD for intergenerational justice and legal conceptualisations of personhood and harm.

Section 3 is a toolkit that showcases a series of critical concepts for biosocial DOHaD research. The first, profiled by Mark Tomlinson, Amelia van der Merwe, Marguerite

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Marlow, and Sarah Skeen, is *lifecourse*, a concept developed in the past 50 years to highlight the role of social and behavioural influences on illness. Edna Bosire, Michelle Pentecost, and Emily Mendenhall's chapter on *syndemics* foregrounds the synergistic characteristics of diseases, calling attention to the importance of studying how diseases cluster and interact across the lifecourse. *Embodiment,* as discussed by Ziyanda Majombozi and Mutsawashe Mutendi, is a social science concept that has been similarly developed to connect the body, subjective experiences, and broader social contexts and is useful to deepen awareness of how social and political factors and contexts influence the development of health and disease over extended periods of time. Sarah Richardson, contends that the ensuing complexity poses a challenge for the field, as DOHaD research investigates causes and effects that are difficult to observe experimentally. She argues that the field is thus characterised by a tolerance to what she calls *causal crypticity* – a characteristic common to many data-rich, postgenomic life sciences. According to Jaya Keaney, Henrietta Byrne, Megan Warin, and Emma Kowal, these difficulties are also evident in research on *intergenerational trauma*, a concept developed to study the long-term physiological consequences of violence and discriminatory social contexts. In the final chapter in Section 3, Elizabeth Roberts and colleagues offer *bioethnography* as a useful interdisciplinary tool for DOHaD research, describing it as a key method and concept to integrate ethnographic research into epidemiological cohort studies.

Section 4 considers how DOHaD research has travelled beyond the lab or academy and into policy and practice. Felicia Low, Peter Gluckman, and Mark Hanson outline the key issues for the field's traction within health policy, while Chandni Maria Jacob, Michael Penkler, Ruth Müller, and Mark Hanson challenge DOHaD researchers to take up insights from communication theory to frame their work in responsible ways for science and society. Involving communities and publics in DOHaD research is an important avenue for creating responsible frameworks, as Siobhan Tu'akoi and colleagues argue in their contribution to community-based participatory methods for translating key DOHaD insights into public health practice in the Cooke Islands. Finally, Anusha Lachman, Astrid Berg, Fiona Ross, and Simone Peters consider how DOHaD ideas are translated into clinical practice, offering the example of the integration of first 1000 days frameworks into a new academic curriculum for infant mental health in Southern Africa.

In Section 5, contributions discuss how biosocial research approaches play out in practice. Emily Emmott and Sahra Gibbon discuss how 'early life' has often been narrowly framed and argue that a biosocial anthropological perspective can contribute to a more nuanced framework for DOHaD-informed research and intervention. Using the example of the HeLTI–South Africa randomised trial, Michelle Pentecost, Larske Soepnel, Khuthala Mabetha, Catherine Draper, and Shane Norris discuss the recent trend towards complex intervention studies within DOHaD. Sophia Rossmann and Georgia Samaras also discuss the challenges of how to adequately capture complex environments in biosocial research, demonstrating that while DOHaD research acknowledges in principle the complexity of lived environments, results often replicate reductionist accounts. Martha Kenney and Ruth Müller's chapter also highlights the importance of framings, by turning their attention to researchers' storytelling practices and how researchers, clinicians, and other actors embed DOHaD knowledge claims as part of larger scientific and societal narratives that have consequences for how DOHaD knowledge circulates in society. Lastly, Shivani Kaul and

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Emily Yates-Doerr discuss DOHaD work in Bhutan and Guatemala that advances relational, interdependent models of development.

Section 6 looks at current trends and possible future directions for DOHaD research. Julie Nihouarn Sigurdardottir and Salma Ayis review moves in DOHaD towards Big Data, artificial intelligence, and machine learning, and the ethical and methodological issues that these innovations represent for the field. Stephanie Lloyd, Pierre-Eric Lutz, and Chani Bonventre offer a case study for how to conceptualise and investigate reversibility as an important concept for DOHaD, using the example of neuroepigenetic research on traumatic memories. Kaleb Saulnier and colleagues discuss the lessons that can be learned from engaging with the interdisciplinary field of disability studies for being inclusive in DOHaD knowledge-making and interventions. They argue that research has often occurred without engaging affected disability communities and point to the importance of the slogan, 'nothing about us without us', for conducting socially responsible research into disability. In a similar vein, Sarah Bourke and Raymond Lovett discuss epidemiological research with, for, and by Indigenous people and how applying an Indigenous lens provides valuable lessons for developing health research and interventions that address the determinants of intergenerational health and well-being in a holistic way. Lastly, Jorg Niewöhner argues that recent scientific developments challenge notions of origin and development that are foundational for DOHaD research and considers new ways of conceptualising DOHaD for the Anthropocene. Drawing on themes that connect the entire handbook, he argues for the vital necessity of interdisciplinary research across the nature–culture divide: only by embracing ideas of anthropogenic biology can DOHaD grapple with the pressing current challenges that face human and non-human life on a planet whose habitability is challenged by multiple crises like climate change and novel planetary health threats.

Together, the chapters highlight the manifold contributions that biosocial research in DOHaD can make to not only rethinking development and health but also to furthering health equity on a planet still marked by persistent and shocking health disparities. The contributions gathered here are a testament to the depth and wealth of biosocial thinking within DOHaD and to the value of interdisciplinary collaborations. The interdisciplinary approach in this volume aims for transformational research, where the outcome 'is a paradigm shift that causes the scientific community to see problems in an entirely different way' [65, p. S21]. The DOHaD research paradigm is inherently transformational, having produced key shifts in biomedical thinking from older chronic disease models to the lifecourse frameworks that are now commonly used for understanding health disparities [2]. The relative youth of the DOHaD field affords further opportunities to radically reshape research practices, and this handbook is both a record of the successes and challenges of this project so far and a toolkit for forging a robust interdisciplinary agenda for transformational research going forward.

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