Chapter 22

Doing Environments in DOHaD and Epigenetics

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22.1 Introduction: Environment as an Elusive Concept

Every organism lives in an environment. We are able to sense, measure, experience, and even change environments. Simultaneously, environments influence and shape us. For scholars in the Developmental Origins of Health and Disease (DOHaD) field, researching environmental effects on health is a key concern: the interdisciplinary field has a long history of drawing attention to the environment and its potential influence on health trajectories by traditionally relying on observational studies in human populations [1].

As scholars from the field of science and technology studies (STS), we are especially interested in understanding what the environment 'is' that emerges in biomedical research and its interactions with our bodies. Such questions prove particularly important in the current postgenomic era, where new scientific research challenges the previous emphasis on the gene as a core explanatory concept for human development by reinvigorating the role of the environment [2].

In recent years, environmental epigenetics has emerged as a key approach towards better understanding disease aetiologies in DOHaD research, which offers scientists a molecular mechanism to trace how environments biologically inscribe themselves into bodies and change health trajectories. Epigenetic research explores how socio-material environments, such as toxicants, stress, nutrition, or poverty, induce biochemical and structural changes on the DNA that impact gene expression, without changing the genetic code itself. In contrast to permanent changes in the DNA (e.g. gene mutations), epigenetic changes are not fixed but allow us to understand bodies as dynamically shaped by the environments in which they live [3].

Although the environment is gaining renewed attention in biomedical research, it still lacks an overarching theoritisation: even in life science publications dedicated to explore the nexus between epigenetics and the environment, scientists barely offer a detailed description of how to theorise the environment that organisms live in. Broad definitions of the environment as multiple factors, for example '[c]hemical pollutants, dietary components, temperature changes and other external stresses' [4, p. 97], reveal that the environment is often conceived of as everything that surrounds cells and organisms. It is a loose definition that foremost understands the environment as distinct from anything genetic [5, 6].

In this chapter, we first discuss how DOHaD research tends to operationalise and measure environments to produce knowledge on how environmental experiences relate to health outcomes. We then show why it is important for researchers to consider how they conceive of and address the environment. We argue that what 'is' the environment is not self-evident but something that needs careful consideration. By scrutinising how

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environments come to matter in epigenetic DOHaD research, we aim to lay the ground for interdisciplinary critical reflections about the social and political dimensions of DOHaD.

22.2 Environments, DOHaD Research, and Environmental Epigenetics

In the twenty-first century, DOHaD has moved towards researching the health effects of a variety of environmental factors. Looking at how complex socio-material environments enter DOHaD research reveals how environments as research objects are not just 'out there'; instead, researchers have to actively *do* environments in the laboratory. For example, in population-based research, DOHaD scientists use measurements such as body mass index or birthweight as indicators for the food environment of cohort participants [7], while in experimental rodent models, food becomes operationalised as a nutrient component [8]. We therefore suggest that how DOHaD researchers are *doing* environments needs careful consideration to understand the consequences that these *doings* might have and for whom.

Social sciences' and humanities' conceptualisations of the notion of environment offer theoretical avenues for how to conceive of the relationship between organisms and the environment in which they live [9]. Understanding this relationship as dynamic and mutually influencing renders stressors not as stressors per se but as phenomena that become stressors *in relation* to an organism. In theory, DOHaD has the potential to provide evidence on how diverse biological and socio-material environments spanning across different scales (intrauterine environment to neighbourhoods to social and economic structures) interact with organisms in a non-linear fashion and impact developing organisms and populations across different temporal horizons (preconception, prenatal periods, infancy, childhood, adolescence, adulthood, and generations). However, operationalising and measuring these dynamic, perhaps 'unfinalizable relations' [10, p. 708] between environments, bodies, spaces, and times is proving to be a challenging task for DOHaD researchers [11].

Social scientists appreciate the potential of epigenetic research to unpack what counts as environments and to reconsider questions of individual and collective responsibility towards these environments, potentially furthering political quests for health equity and social and environmental justice [12, 13]. At the same time, they frequently criticise that concepts of environments in the life sciences tend to be too simplistic [14] or lack consensus over what is meant by 'environment' [15]. There are three central social science critiques on how epigenetic DOHaD research operationalises the environment.

First, social science scholars have pointed out that epigenetic research tends to reduce complex environments to how environmental factors have an effect on the molecular level. For example, Landecker [16] demonstrates how research in nutritional epigenetics reconfigures the complexity of food to a molecular exposure capable of changing epigenetic mechanisms and the metabolism: what we eat has come to be framed as an epigenetic environment, that is an external exposure that conditions the (prenatal) body for later-life health outcomes such as diabetes or heart diseases.

This 'molecularization of biography and milieu' [3] that is rendering complex environments, relationships, and histories in terms of their molecular effects on bodies has been cautioned against also by DOHaD researchers in interdisciplinary collaboration.

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Social and life scientists together have argued how such an understanding might obscure how these exposures are socially patterned and unequally distributed across the social worlds we live in [17, 18].

Second, social science scholarship has discussed the potential of DOHaD research to individualise environments. As Chiapperino et al. extensively discuss in this handbook, epigenetic DOHaD research tends to focus on individual behaviours and traits as primary sites to make environmental exposure visible. This focus can be problematic as neglecting how structural factors impact health beyond individual decisions can lead to rendering exposure situations as products of lifestyle decisions, thereby favouring behavioural over structural health interventions. Thus, individuals might be responsiblised for managing their health risks and diseases [17].

Interestingly, as Warin et al. [19] outline, DOHaD research originally had a focus on how gendered socio-economic effects of maternal undernutrition impact the disease susceptibilities encountered in adulthood. However, with an increasing focus on overnutrition, maternal obesity, and diabetes, DOHaD's notions of the environment have become narrower over time, 'telescoping' on the uterus as '"the environment" of scrutiny; ... the social environment [became] an independent and secondary context'. [19, p. 456]. Such tendencies to become more concerned with individual-level factors and choices also speak to a gendered stereotype of female caregiving that is especially prevalent in the Global North and perpetuates culturally situated concepts of the environment as singular and bounded [12].

Lastly, social scientists have argued how specific experimental set-ups in epigenetic DOHaD research give more attention to some environments than others [20]. Studying clinical trials in the UK and USA, Valdez [14] demonstrates how with selecting some experimental set-ups (e.g. animal models and randomised clinical trials), researchers choose certain environmental factors as significant over others, ultimately influencing what public health professionals regard as central for designing and implementing interventions. These choices often stem from the epistemological traditions of scientific fields. For example, in social epidemiology, diet might be access to different types of food shaped by socio-economic structures [20]. In comparison, nutritional epigenetics operationalises diet as environmental exposures in the form of nutrients [16], whereas in the mundane experiences of family meals diet, even if considered unhealthy, might be interpreted as expressing love to one's family members [21].

22.3 Caring for More Complex Environments in DOHaD Research

With environments playing a central role in DOHaD research, we believe it is important to consider *how* scientists measure and operationalise environments. As findings are increasingly taken up in healthcare and global policy guidelines [22], they have social and political consequences for wider society. They shape how society understands diseases, (re-)assigns responsibilities towards tackling them, and what health strategies and interventions are imagined possible. If framings of the environment are mostly done on the individual level and as simplistic factors, they steer interventions in the direction of educational public health messaging and lifestyle changes rather than examining the structures that undergird certain choices (cf. Chapter 16).

However, this does not mean that DOHaD researchers do not engage in reflections on the complexity of human lives. Penkler [11] shows how the simplistic environments

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emerging in DOHaD study designs are sometimes 'at odds with the researchers' own normative commitments and aspirations' and their aim to position themselves against the 'reductionist science' (p. 2) of gene centrism in the 1990s and 2000s.

Looking at very recent developments in DOHaD fields provides interesting cases of researchers' attempts to conceptualise environments in more complex ways and to shift attention to environments that might have a positive effect on health trajectories. Informed by our own ethnographic fieldwork in environmental epidemiology (Rossmann) and neurobiology (Samaras), we briefly discuss two examples: green spaces and stress as a complex experience. Both examples exhibit a fundamental question that receives renewed attention with environmental epigenetics: how can DOHaD research account for the entangled relationship between organisms and environments?

22.3.1 Green Spaces

Green spaces (e.g. parks) have been associated with a plethora of beneficial health outcomes such as improved physical and mental health and a lowered risk of cardiovascular and respiratory diseases. Treated as an exposure variable, green spaces tend to be operationalised using established variables available and harmonised across different cohort studies. These variables currently include (1) surrounding greenness using satellite-derived indices to quantify the intensity of greenness; (2) access to a green space within 300 metres of residence; (3) straight line distance to the nearest green space; and (4) area of the closest green space.

Yet, what green spaces 'are' at the specific institute for epidemiology and public health at which Rossmann conducted her fieldwork is not fixed from the start but instead the outcome of a series of negotiations among the researchers. Rossmann could observe how green spaces are done in practice: in scientific articles, international guidelines, through infrastructures and their available data sets, and in scientific meetings. Researchers actively assemble the variable 'green spaces' using different types of aggregated data, including satellite images, topographical maps, questionnaires, measurements, and experiences through particular modes of calculation. They reflect upon its *temporal* dimension measured as the greenest moment of the year and time spent in green spaces; *spatial* dimension measured quantitatively as distance, access, and size and qualitatively emphasising the importance of local environments; and *social* dimension considering how people might experience and use these spaces differently, where green spaces can create both restorative effects and stressful experiences when perceived as dangerous.

At the end of these negotiation processes, the group Rossmann followed will have decided to focus on two variables to analyse for one of their first publications on epigenetic changes in relation to exposure to green spaces: greenness and access. These two variables will appear as clear-cut definitions of green spaces in their publication, momentarily stabilising a specific version of green spaces reintegrated into the classical terminology of exposure variables while excluding the process that went into deciding upon them.

22.3.2 Stress as a Complex Experience

The experience of stress has long been a subject in neurobiological research. This branch of research describes stress as having a potential pathogenic effect, leading to depression or anxiety, especially when considered severe or occurring over a long period of time.

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Rendered as an environmental exposure, neurobiologists tend to operationalise stress by eliciting a systemic response, for example by placing mice into a narrow tube to measure the traces stress leaves behind as changes in DNA methylation or histone modifications. In these re-enactments, stress is reduced to (a series of) singular measurable events that challenge organisms, obscuring how stress is omnipresent in a lab rat's life, for example through differences in their handling or housing.

The work of the research group with which Samaras conducted her ethnographic fieldwork contrasts with this reductionist approach. The group attempts to invite a more complex notion of environment into the mouse model by including what they term 'social' factors: they create a completely new experimental arena for the mice to live in to construct a 'semi-natural' or 'enriched' environment that allows the researchers to test the mice in groups. This highly sophisticated experimental arena, termed 'complex behaviour', consists of various interconnected cages in which the mice are offered toys, food, and water at all times. By extending the experiment over several days during which the mice experience exposure to stress, undisturbed phases, and even positive environments (toys), researchers attempt to emphasise the temporal dimension of the environment and to account for the dynamics of experiencing stress. Stress emerges as a processual experience that spans across life instead of singular events that are disconnected from most parts of an organism's life. The 'complex behaviour' set-up therefore allows researchers to understand stress as an environmental phenomenon proceeding in action, where the mouse is triggered and then equilibrated, triggered again, and so forth.

Both examples demonstrate that it matters to care for constructing more complex exposure variables and research arrangements. First, these examples illustrate current developments in DOHaD to move away from a historically strong emphasis on 'damaged-centred' [23] research towards environments with buffering and restorative effects. Green spaces, for example, are assembled as elements of the urban environment that can have buffering effects, counterbalancing adverse health trajectories. Similarly, the 'complex behaviour' experiment offering 'enriched environments' encourages conversations on how positive social interventions, especially early in life, might have therapeutic effects [cf. 24]. Taking seriously the dynamic and processual character of environments across time increasingly means for DOHaD researchers to also consider 'positive' environments.

Second, these more complex renderings of environments shift attention away from dominant interventions on the individual level towards understanding organisms embedded in the ecologies in which they live. Evidence on green spaces is directed at policymakers to raise questions on how to design the cities where we want to live. 'Complex behaviour' experiments shift attention to how certain variables of interacting life circumstances shape health outcomes.

22.4 Obstacles to Put Complex Environments into Practice

As outlined in the previous section, DOHaD researchers discursively care about acknowledging the dynamicting character of environments, with some moving towards incorporating more complexity into the study designs. Simultaneously, most DOHaD researchers grapple with this complexity: being embedded in institutional contexts and established infrastructures hampers scientists to put their complex understanding of environments into practice [11]. We see three obstacles arising from the current disciplinary and research policy structures from putting main drivers of this challenge.

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First, while constructing environments as phenomena taking place over time carries more ecological validity, this poses new challenges as to how to turn these considerations into research set-ups that capture the dynamic relations. Ackerman et al. [25] identify a 'moral economy of quantification', which arises from the dominant and collectively negotiated virtues in science that 'shape ... how knowledge about complex causality can be produced.' (p. 213). This moral economy favours operationalisations of environments that can be turned into 'precise measurements' and data to be harmonised and traded across laboratories. Such aspirations to produce universal data incentivise researchers to focus on environments that are easier to manage in the laboratory, making it unrewarding to operationalise environments as experiences arising from structural circumstances.

Second, these epistemological reasons are intertwined with the power of current research infrastructures and framework conditions in the life sciences [26]. As Pinel [27] points out, the biological environment to trace how exposures and experiences produce epigenetic changes is embedded within a social environment of the entrepreneurial university where research is conducted. This environment is structured and influenced by multiple overlapping scales of funding bodies, audit cultures, peer-reviewed journals, and scientific communities and their established practices. Thus, decisions on how to operationalise environments are not only guided by the research questions but also depend on institutional settings, economic aspects (e.g. time and material resources), and technical infrastructures (e.g. computing power available for statistical analyses) [27].

Third and relatedly, the current and rather rigid logic of publishing may not allow to include how researchers negotiate which environments to re-enact and how. Life science publication culture is mostly geared towards representing research as linear and producing unambiguous results. We know from STS that research practices are tedious processes in which scientists have to negotiate what materials and methods they in-/exclude, how, and why [28]. To account for these local and situated experimental conditions that bring about the final research results, as discussed above with green spaces and stress, would require a new publication ethos that allows research to be portrayed as a dynamic and social process, for instance, in the form of an extended Materials & Methods section [29].

22.5 Conclusions: Avenues for Interdisciplinary Conversations

The environment represents an elusive concept to capture for biomedical research. With findings from DOHaD research becoming increasingly relevant for policy and healthcare [22], it matters how scientists conceive of and address the environment. In order to conceptualise environments that allow for more complexity in research designs, we discuss the merits of interdisciplinary collaboration in which social and life scientists *together* engage in critical reflections about the social and political dimensions of DOHaD.

On the epistemological level, including certain environments in research designs is necessarily selective to become workable: most research has to be reductionist to a certain degree to be feasible. Engaging in these kinds of 'pragmatic reductionisms' [30] demands reflections on the strategic choices and trade-offs made and their potential political consequences outside the scientific arena. To take this task seriously, we

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consider it important for both, DOHaD researchers and social scientists, to critically and responsibly question their own practices: being aware of which reductionisms they want to engage in, that is which reductionisms they potentially reproduce with their research and still comply with.

On the practical level, interdisciplinary collaborations could help provide more complex accounts of the biosocial environments that shape health trajectories across the lifespan and generations. Examples of the forms that these collaborations can take can be found in this handbook (Chapters 15 and 29). Roberts et al., for example, propose the method of *bioethnography*, which combines ethnographic observation and biochemical sampling and encourages both social and life scientists to engage in an open-ended and iterative process of doing research.

Niewöhner advances the term 'co-laboration' to think about interdisciplinary collaborations, as he argues elsewhere, in terms of 'temporary, non-teleological, joint epistemic work aimed at producing disciplinary reflexivities not interdisciplinary shared outcomes' [31, p. 2]. In other words, interdisciplinary work is not about giving up on one's own disciplinary positioning but encouraging spaces to think differently about one's own knowledge practices. Such spaces to engage in processes of mutual learning emerge from encounters in 'reading groups, joint empirical work, visiting conferences together, writing together, designing and conducting experiments together' [31, p. 18].

We propose that such interdisciplinary collaborations, even when situated in divergent research ecologies, prove fruitful to further discussions on *doing environments*. We suggest five (non-exhaustive) reflections for these discussions to account for the different epistemological and socio-political dimensions environments are made up of in DOHaD research:

1. to discuss *doing* environments as an active achievement, that is as a product of the decisions made and methods used to know and measure environments (performative dimension);
2. to take seriously the temporal dimensions of environments beyond their re-enactments as singular damage in the laboratory (processual dimension);
3. to carefully consider how environments as research objects are embedded in the (research) contexts in which they occur, that is to acknowledge accounts of environments as historically, socio-politically, and economically influenced (situational dimension);
4. to understand *doing* environments as political, bearing potential consequences for which environments become relevant outside the scientific arena (political dimension);
5. and to allow for interdisciplinary reflexivity to identify blind spots in defining environments across disciplines (reciprocal dimension).

We hope that these reflections further encourage interdisciplinary conversations about the importance of carefully attending to how environments are done in DOHaD research. We consider it necessary to acknowledge *doing environments* as a concrete research practice and as a repertoire in scientific discourse, instead of leaving this central scientific task undiscussed. In doing so, DOHaD researchers could, for example, take into account environments beneficial to organisms and invest in studying the effects of 'enriched' environments [24]. This could open up discussions about the restorative effects of social interventions and help address structural problems in public health

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policy [cf. 13]. Here, we see a great opportunity to go beyond individualised and damage-centred narratives in DOHaD research in order to tell scientific stories that account for the complexity of biosocial worlds.

References

1. Gluckman PD, Buklijas T, Hanson M. The Developmental Origins of Health and Disease (DOHaD) concept: Past, present, and future. In: Rosenfeld CS, ed. The Epigenome and Developmental Origins of Health and Disease. Boston, MA, Academic Press. 2016; 1–15.
2. Richardson SS, Stevens H, eds. Postgenomics: Perspectives on Biology after the Genome. Durham, NC, Duke University Press, 2015.
3. Niewöhner J. Epigenetics: Embedded bodies and the molecularisation of biography and Milieu. BioSocieties 2011; **6**(3): 279–98.
4. Feil R, Fraga MF. Epigenetics and the environment: Emerging patterns and implications. Nature Reviews Genetics 2012; **13**(2): 97–109.
5. Pinel C, et al. Markers as mediators: A review and synthesis of epigenetics literature. BioSocieties 2018; **13**(1): 276–303.
6. Darling KW, Ackerman SL, Hiatt H, Lee SS-J, Shim JK. Enacting the molecular imperative: How gene-environment interaction research links bodies and environments in the post-genomic age. Social Science & Medicine 2016; **155**: 51–60.
7. Uchinuma H et al. Gestational body weight gain and risk of low birth weight or macrosomia in women of Japan: A nationwide cohort study. International Journal of Obesity 2021; **45**(12): 2666–74.
8. Jirtle RL, Skinner MK. Environmental epigenomics and disease susceptibility. Nature Reviews Genetics 2007; **8**(4): 253–62.
9. Ingold T. The Perception of the Environment: Essays on Livelihood, Dwelling and Skill. London, Routledge, 2000.
10. Warin M, Martin A. Emergent postgenomic bodies and their (non) scalable environments. In: Meloni M, Cromby J, Fitzgerald D, Lloyd S, eds. The Palgrave Handbook of Biology and Society. London, Palgrave Macmillan. 2018; 703–25.
11. Penkler M. Caring for biosocial complexity. Articulations of the environment in research on the Developmental Origins of Health and Disease. Studies in History and Philosophy of Science 2022; **93**: 1–10.
12. Warin M, Kowal E, Meloni M. Indigenous knowledge in a postgenomic landscape: The politics of epigenetic hope and reparation in Australia. Science, Technology, & Human Values 2020; **45**(1): 87–111.
13. Müller R, Kenney M. A science of hope? Tracing emergent entanglements between the biology of early life adversity, trauma-informed care, and restorative justice. Science, Technology, & Human Values 2021; **46**(6): 1230–60.
14. Valdez N. The redistribution of reproductive responsibility: On the epigenetics of 'environment' in prenatal interventions. Medical Anthropology Quarterly 2018; **32**(3): 425–42.
15. Shostak S, Moinester M. The missing piece of the puzzle? Measuring the environment in the postgenomic moment. In: Richardson SS, Stevens H, eds. Postgenomics: Perspectives on Biology after the Genome. Durham, NC, Duke University Press. 2015; 192–209.
16. Landecker H. Food as exposure: Nutritional epigenetics and the new metabolism. BioSocieties 2011; **6**(2): 167–94.
17. Penkler M, et al. DOHaD in science and society: Emergent opportunities and novel responsibilities. Journal of

https://doi.org/10.1017/9781009201704.024 Published online by Cambridge University Press

Developmental Origins of Health and Disease 2019; **10**(3): 268–73.

18. Müller R, et al. The biosocial genome? Interdisciplinary perspectives on environmental epigenetics, health and society. EMBO Reports 2017; **18**(10): 1677–82.
19. Warin M, Moore V, Zivkovic T, Davies M. Telescoping the origins of obesity to women's bodies: How gender inequalities are being squeezed out of Barker's hypothesis. Annals of Human Biology 2011; **38**(4): 453–60.
20. Shostak S, Moinester M. Beyond geneticization: Regimes of perceptibility and the social determinants of health. In: Bell SE, Figert AE, eds. Reimagining Biomedicalization, Pharmaceuticals, and Genetics: Old Critiques and New Engagements. New York, Routledge. 2015; 216–38.
21. Roberts E. Food is love: And so, what then? BioSocieties 2015; **10**: 247–52.
22. Pentecost M, Ross F. The first thousand days: Motherhood, scientific knowledge, and local histories. Medical Anthropology 2019; **38**(8): 747–61.
23. Tuck E. Suspending damage: A letter to communities. Harvard Educational Review 2009; **79**(3): 409–27.
24. Chiapperino L. Environmental enrichment: An experiment in biosocial intervention. BioSocieties 2019; **16**(1): 41–69.
25. Ackerman SL, Darling KW, Lee SS-J, Hiatt RA, Shim JK. Accounting for complexity: Gene–environment interaction research and the moral economy of quantification. Science, Technology & Human Values 2016; **41** (2): 194–218.
26. Müller R, de Rijcke S. Thinking with indicators. Exploring the epistemic impacts of academic performance indicators in the life sciences. Research Evaluation 2017; **26**(3): 157–68.
27. Pinel C. What counts as the environment in epigenetics? Knowledge and ignorance in the entrepreneurial university. Science as Culture 2022; 1–23: 311–33.
28. Knorr-Cetina KD. The Manufacture of Knowledge: An Essay on the Constructivist and Contextual Nature of Science. Oxford: Pergamon, 2013.
29. Samaras G. Re-Enacting Stress in the Lab. On Environmental Epigenetics, Social Adversity and the Molecularisation of Mental Health. Unpublished PhD thesis, Technical University of Munich, 2020.
30. Beck S, Niewöhner J. Somatographic investigations across levels of complexity. BioSocieties 2006; **1**(2): 219–27.
31. Niewöhner J. Co-laborative anthropology: Crafting reflexivities experimentally. In: Jouhki J, Steel T, eds. Ethnologinen Tulkinta ja Analyysi. Kohti Avoimempaa Tutkimusprosessia. Helsinki, Ethnos. 2016; 81–125.

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