

## Interdependence

### Reworking Ontogeny through *Tendrel* Fishbones and Dirty Chickens

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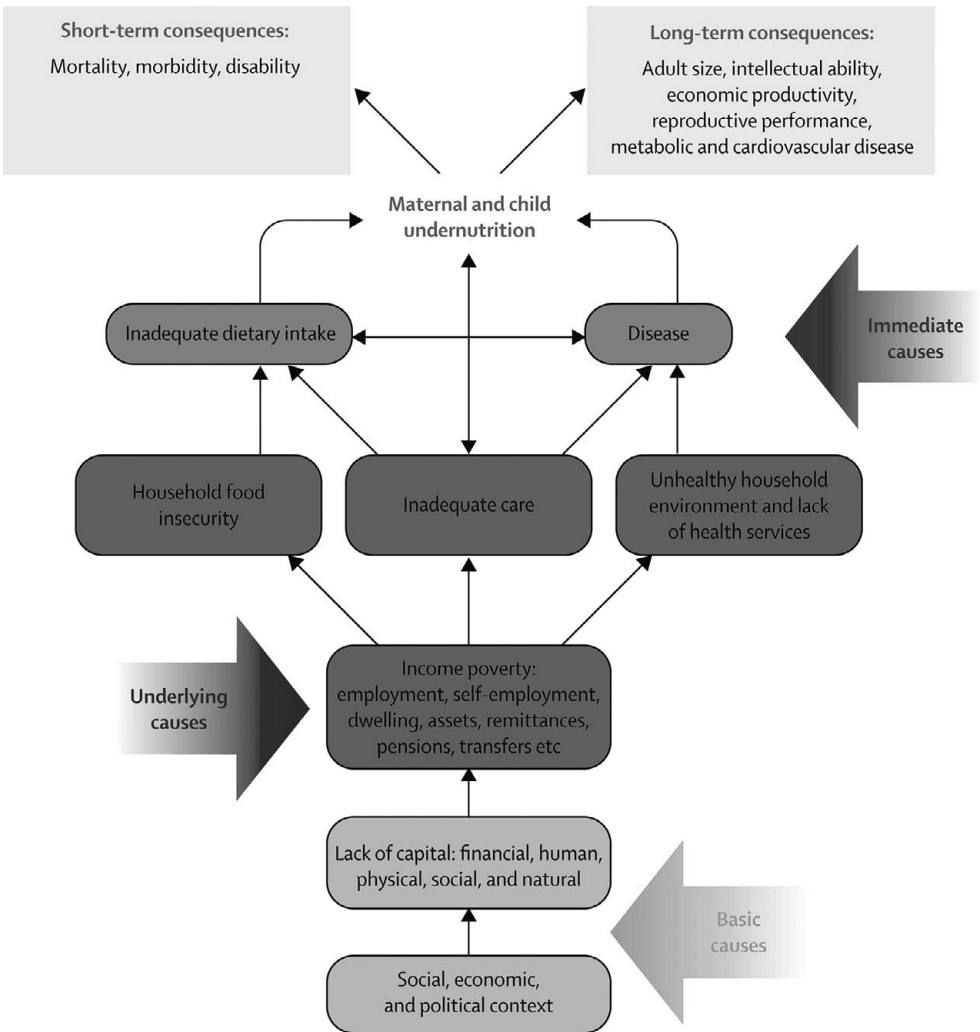
#### 24.1 Introduction

In 2008 and 2013, *The Lancet* published a series on maternal and child undernutrition that laid the groundwork for public health policymakers to approach nutrition as a foundational component of global development. In the series introduction, Robert Black and his co-authors emphasise a hierarchy of medical and monetary factors that cause malnutrition and serve as sites for intervention. Using a framework developed by UNICEF, they list eight color-coded risk factors, all stacked vertically [1]. ‘Basic’ causes of malnutrition like ‘social and economic conditions’ and ‘lack of capital’ sit at the bottom of the stack (see Figure 24.1). Then come monetised ‘underlying’ conditions like ‘income poverty’, which is listed prior to and distinct from conditions like ‘unhealthy household environment’. At the top of the stack, closest to undernutrition, are ‘immediate’ causes such as ‘inadequate dietary intake’ and ‘disease’. In the first article of the series, Geneva and US-based authors emphasised the period from conception to the second birthday – a period of roughly 1000 days – as a ‘crucial window of opportunity’ to address undernutrition [2, p. 510]. The series’ second article emphasises the health and ‘human capital’ consequences of malnutrition. Here, the multidisciplinary authors draw on the Developmental Origins of Health and Disease (DOHaD) hypothesis to argue that poor fetal nutrition in early life leads to ‘irreversible damage’ to future adult health, school achievement, and adult income for up to three generations [3, p. 340].

The dominant logic woven through this publication series is that a narrow window of physiological development has profound implications for future health and economic productivity, which neoclassical economists value for its contribution to gross domestic product (GDP). Though the potential nutrition interventions discussed in these papers range from land reform to rest during pregnancy, most ‘proven’ nutrition interventions the authors recommend focus on what they call immediate causes. The third article illustrates the overarching message of the series: that policy actions on maternal and child undernutrition can include a wide range of interdependent interventions while excluding ‘important interventions that might have broad and long-term benefits’

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**Figure 24.1** The *Lancet* model of causal interdependence [1, p. 244]

because they are ‘outside the scope’ of review, or because they lack an appropriate evidence base appropriate evidence like randomised control trials [4, p. 418]. ‘We must be targeted in our approach’, one US-based politician has said about the need to address malnutrition during the early developmental stages (see also Jacob et al. in this volume).

In our chapter, we draw upon research on child development that inspires a reworking of *The Lancet*’s causal models and the policies that result. The DOHaD scientists in Bhutan and Guatemala whose work we describe are in conversation with *The Lancet*’s series on child development. But whereas *The Lancet*’s authors place ‘social, economic, and political’ factors at the edge of the conversation about child development, these scientists place cultures, economics, politics, and ecologies squarely at the heart of development, advancing a theory of ontogeny that insists on a complex and interdependent web of causation.

Ontogeny (from the Greek words onto/being and genesis/birth) is a term biologists use to describe physiological growth and development. It emphasises how an organism’s

form emerges through a process of temporal maturation, with early-life inputs coming to shape later-life physiological structures. This chapter illustrates how different scientific models for ontogenic (biological) development shape the terrain of possibility for global (economic) development, which warrants attention since scientists' vision of development impacts the interventions they design. In Bhutan, we highlight the example of 'fishbone' modelling that unfolds child development factors along multiple, horizontal, spatial, and temporal themes. That child development is the effect of collective well-being amplifies Buddhist relational logics of *tendrel*, or interdependent origination. In Guatemala, we highlight the example of the 'dirty chicken hypothesis', which directs attention to ecological relations. In the Guatemalan case, the normative question of how the organism should develop is one that requires also asking whether the environments that shape and surround this development are well supported.

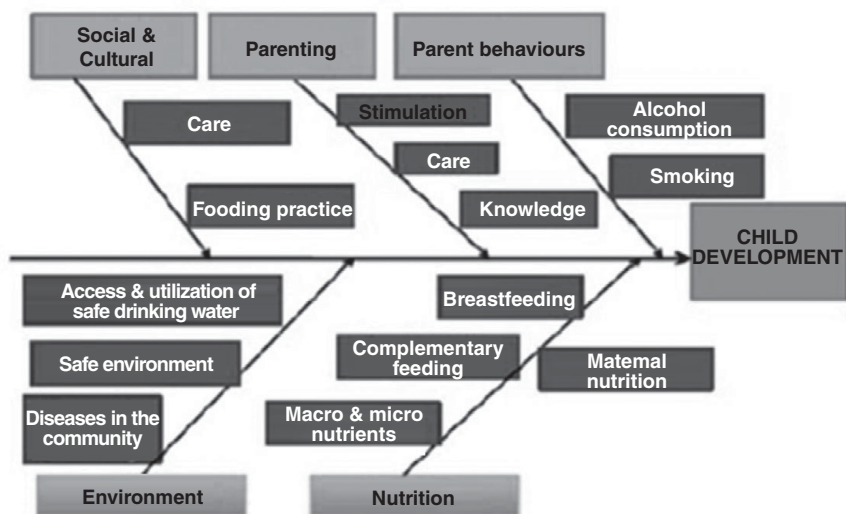
While *The Lancet's* models and the Bhutanese and Guatemalan models for malnutrition all emphasise interdependence between humans and their surroundings, they differ in how they organise this interdependence, and, as a result, where the work of intervention must fall. Whereas *The Lancet's* models are linear and hierarchical, resulting in a policy focus on what and how mothers eat, the theories of interdependent ontogeny that we describe in Bhutan and Guatemala insist upon the value of an ecological approach to health policy, where any given intervention must be reformulated away from targeting individuals to instead amplify caring coalitions. 'Target', we learn from this theory of ontogenesis-as-interdependence, is frequently the wrong metaphor: human communities and landscapes must be cared for together.

## 24.2 Bhutan: The Fishbone Model

### 24.2.1 The Golden 1000 Days

Since 2008, the Geneva-based organisation Scaling Up Nutrition (SUN) has been rallying governments, multinational corporations, and non-profit organisations to fund 13 'high impact' interventions selected from *The Lancet* series. The organisation has become 'the most important symbol for the increased interest in nutrition' in global development today [5, p. 552]. Leaders in food policy from 65 countries have joined SUN so far. But some governments have not been so quick to sign up for this targeted approach to intervention and financing. In 2016, the Royal Government of Bhutan sent three representatives to Bangkok to attend the SUN workshop on public finance for nutrition in Asia. Bhutanese representatives did not join SUN, instead citing the need to complete more research on broader actions that follow different pathways of maternal health.

Scientists and policymakers in Thimphu, the capital of Bhutan, have been mobilising over the last decade around a range of interventions related to the first 1000 days agenda, known locally as the 'Golden 1000 Days'. This agenda has generated passionate public discourse within Bhutan – a country never directly colonised, in which an alternative philosophy of economic development circulates named Gross National Happiness (GNH). The agenda's proposed interventions include standard actions like micronutrient powders, breastfeeding and nutritional counselling, and conditional cash transfers, but also broader socio-economic interventions such as six months of paid maternity leave for all civil servants. Additionally, the Golden 1000 Days builds on existing development policies to ensure GNH or collective well-being, including the constitutional protection of 60 per cent



**Figure 1:** Fish bone diagram for child development causality. Fish bone diagram presenting the factors affecting child development.

**Figure 24.2** The ‘fishbone’ model of causal interdependence [6, p. 2]

of the country’s forest coverage, free education, and fully state-funded biomedical and Sowa Rigpa (Tibetan) healthcare, with an emphasis on primary care [6].

## 24.2.2 Developing Differently

While *The Lancet* authors model the causes of malnutrition through hierarchical, monetary, and medicalised factors, Bhutanese scientists emphasise interdependence across causal domains – adopting a more horizontal and multidisciplinary approach to addressing undernutrition. Take, for example, the work of Deki Pem, Deputy Dean of Nursing & Midwifery at Khesar Gyalpo University of Medical Sciences in Bhutan. When conceptualising The Golden 1000 Days agenda in Bhutan in 2015, Deki published a ‘fishbone’ diagram for child development designed to model cause and effect [7]. The ‘fishbone’ is a conceptual tool that identifies multiple factors that could be contributing to unanticipated outcome variation developed by Japanese organisational theorist Kaoru Ishikawa in the 1970s. Deki used this modelling technique to fan out the potential risk factors for undernutrition to 14 factors (see Figure 24.2). She organised these factors horizontally, not vertically. Instead of separating and then ordering undernutrition’s causes into basic, underlying, and immediate causal classes, the ‘fishbone’ model brings concerns for the environment, society, and culture, parental care, and eating into the conversation of ontogeny. Collective norms of care appear along the sociocultural rib, and safe drinking water features in the environmental rib. What women themselves eat or feed their children becomes a small part of this causal map.

Multiplying the causal origins of child development opens up alternative strategies for nutrition intervention and research. Approaching the Golden 1000 Days through the ‘fishbone’ model, it becomes difficult to imagine designing effective interventions targeting what women eat – though economists and nutritionists working for the Ministry of Health and international organisations like the World Bank do promote micronutrient sachets and behaviour change interventions in Bhutan [8, 9]. As a nursing practitioner and medical university instructor, Deki has been concerned about customary alcohol use during pregnancy and first food practices that might disrupt exclusive breastfeeding, but her horizons were open. A wide range of remaining known unknowns compel her work – from inter-generational changes in the relationship to food and childcare due to rural-urban migration to the capital Thimphu, to potential sources of environmental lead exposures.

Over a shared plate of *omurice*, Deki explained to Shivani her recent collaborative research on elevated blood levels among children in Thimphu and Phuntsholing. The specific concern in this study on undernutrition was anaemia, ‘a critical public health problem in Bhutan’, with indicators that had not improved in over 18 years [7, p. 2]. The multiplication of causal factors involved in ontogenetic development also invites multi-disciplinary collaboration. With a coalition including physicians, medical statisticians, nursing faculty and anthropologists, Deki has pivoted from studying feeding practices to studying environmental exposures.

Their recent research showed that about 44 per cent of a sample of children between two months and five years of age from the capital city Thimphu and the industrial border town of Phuntsholing had elevated blood lead levels [10]. Deki and her co-authors were surprised to find a significantly higher prevalence of elevated blood lead levels among the children living in otherwise ‘clean’ Thimphu, in spring, and those who regularly eat with their hands. Their findings indicate the need for more research on the role of ‘demolition and construction, weather differences, and possible water contamination’, in childhood malnutrition [10, p. 12]. Environmental exposures potentially have knock-on effects on iron deficiency, anaemia, and undernutrition, confirming the need to multiply the sites of research and to rethink the strategy for nutrition interventions during the Golden 1000 Days.

### 24.2.3 *Tendrel* Interventions

*The Lancet*’s diagram for ontogeny dismissed ‘social, economic, and political context’ factors for development as too difficult to operationalise in health interventions. Meanwhile, Deki Pem and other malnutrition researchers in Bhutan have highlighted the need to care about what and how different generations of people eat, what social supports they encounter, and the unevenly contaminated environments in which they live. Rather than causally write off ecology and history as ‘distant’, the scientific practice of Deki Pem and her colleagues enacts a vision for development where socioeconomics, culture, history, diet, safe living environments, water quality, and so on could all be understood as ‘immediate’ contributors to conditions of inequitable nutrition outcomes. One factor does not precede another in importance; likewise, quick or targeted interventions are not necessarily more effective than those with a slower temporal horizon.

The ‘fishbone’ diagram of child development amplifies the causal logic of *tendrel* or interdependent origination, which informs health practice in Bhutan. Physician historians Tandi Dorji and Bjorn Melgaard articulate how Buddhist theories of causality facilitate health interventions that open a multiplicity of interdependent factors:

The concept of interdependence of all phenomena, that nothing exists as a separate entity but as a part of the whole, is one of the fundamental beliefs in Buddhism. When considering health and disease, this concept implies that the person with the illness must be viewed in relation to the whole, i.e. all internal and external factors that the person is dependent upon, such as physical, mental, social, moral, environmental, familial, work, diet, etc. [11, p. 25].

While this may sound romantic, *tendrel*, in its evocation of being dissimilar but related, emphasises the need to cooperate across difference – across scales and sites. *Tendrel* emphasises the co-arising of beings as an impermanent and indeterminate process of relationship, according to the cultural historian Karma Phuntsho [12]. From this causal logic of interdependence, it is important to discern which relations are generative and which relations are harmful. As much as connecting or adding relations, identifying and refusing toxic attachments becomes key for development and collective well-being. Human interdependence with landscapes is a distinguishing causal feature of Sowa Rigpa and healing practices in Bhutan [13] and has also influenced how complex global health problems like pandemics have been addressed through coalitions and careful refusal of global market relations [14].

Incorporating *tendrel* into child development policy shifts how DOHaD-informed nutrition interventions might be designed. In contrast to short-term interventions to address immediate causes, policymakers must identify and act upon the multiple conditions that contribute to a given goal. From the interdependent causal logic of *tendrel*, effectively intervening in the ontogenesis of undernourished bodies requires working in multidisciplinary coalitions to address a wide range of cultural, political, and ecological conditions. This attention to the ‘gradual unfolding’ of child development is what Deki Pem’s fishbone diagram and scientific practice opens up [7, p. 1], reminding policymakers why the Golden 1000 Days in Bhutan would not be possible without development actions as expansive as tending to natural resources like forests, providing free biomedical and Tibetan healthcare, and free public education.

## 24.3 Guatemala: The Dirty Chicken Hypothesis

### 24.3.1 Nutrition as an Interdisciplinary Science

In the mid-1970s, Dr Nevin Scrimshaw, the founding director of the United Nations’ *Institute of Nutrition of Central America and Panama* (INCAP), recommended one of his former students, Noel Solomons, for a research position at the institute’s headquarters in Guatemala City. In operation since 1949, INCAP has become a key international centre for science and policy on child development. Guatemala, a country that was roughly half-Maya with a long history of resistance to colonial conquest, is also reported to have high rates of hunger and malnutrition. Americas. INCAP was founded with the goals of learning about the biology of nutrition and carrying out policy interventions to act upon this knowledge.

Both Solomons and Scrimshaw held medical degrees, with specialisation in clinical nutrition, but they were also both interdisciplinary and expansive thinkers. Scrimshaw was widely known for his knowledge of biochemistry, but after a decade at INCAP he took a sabbatical break at Harvard to complete a master’s degree in Public Health. His 1959 thesis examined the ‘Interactions of Nutrition and Infection’ to make the argument that malnutrition enhanced the susceptibility to infection, while the burden of infection impaired the acquisition and retention of nutrients. Solomons would later call this Scrimshaw’s ‘most transcendental conceptual synthesis’, [15] celebrating Scrimshaw’s talent for making crucial connections across vastly different domains of expertise.

Solomons, a Black man from Boston whose paternal grandparents were raised on the Dutch island colony of Aruba and who self-identifies in policy spaces as a feminist, was also accustomed to linking diet to broader social contexts, including those of imperialism, colonialism, and social oppression. In addition to holding a medical degree from Harvard, he was trained in internal medicine and infectious disease at the University of Pennsylvania and in gastroenterology and clinical medicine at the University of Chicago. His inclination towards systems thinking afforded him insight into the shortcomings of studying nutrients in isolation. He is fond of pointing out that an understanding of the human body requires a deep understanding of the surrounding environment. To the adage that people eat food, not nutrients, Solomons has added his insight that people don't just eat food, but they ingest adverse influences from certain social and ecological environments.

### 24.3.2 Contaminated Ecologies

In 1985, Solomons split with INCAP to found his own nutrition research centre in Guatemala City, named the *Center for Studies of Sensory Impairment, Aging, and Metabolism* out of the recognition that nutrition was linked to the development of metabolic and sensory integration processes. Among the hundreds of scientific articles and briefs Solomons has published over the last half-century, he is especially fond of a 1993 paper titled 'The Underprivileged, Developing Country Child: Environmental Contamination and Growth Failure Revisited', which advances what he calls 'the dirty chicken hypothesis'. This is an allusion to the phenomenon well known by poultry scientists that chickens would not grow or put on meat when reared in unsanitary surroundings despite an abundance of feed. A background concern animating the publication is that the public health nutrition community is overly focused on diet. In contrast, Solomons et al. write that 'poor growth appears to be strongly influenced by environmental factors as well as nutrition' [16, p. 327].

With an eye to veterinary science, Solomons observed that veterinarians had long known that animals raised in cleaner conditions – or, alternatively, animals who were fed a low-dose supply of antibiotics to ward off repeated inflections – grew bigger than those raised in contaminated growing conditions. Growth failure in humans, he and his co-authors argued in this 1993 paper, might similarly be more influenced by 'recurrent, overt infections of the respiratory and gastrointestinal tracts', than by whatever foods people are, or are not, eating. He explained that frequent microbial infections brought about by poor sanitation will 'result in continual activation of the immune system and specific metabolic changes' [16, p. 329]. These infections were often 'inapparent' – that is they were not visible to the naked eye or perceived by the person living in these conditions – but they nonetheless led to the condition of 'immunologic stress' and hampered growth. The paper proposed that monokines such as interleukin, tumour necrosis factor- $\alpha$ , or interleukin-6 become caught up in an immune response that alters metabolism. They write,

The metabolic changes represent a homeorrhetic response that alters the partitioning of dietary nutrients away from growth and skeletal muscle accretion in favour of metabolic processes that support the immune response and disease resistance. These changes form the basis for impaired growth and feed utilization, and for altered nutritional requirements in chicks [16, p. 329].

A human child is, of course, not a baby chicken, but the scientists saw that their observation about chicks might influence the science and policy of human development.

In the background of the dirty chicken article is Solomons' critique of the field of public health nutrition for taking a 'monolithic' approach to malnutrition, overly focused on dietary supplementation. One of Solomons' scientific domains of expertise is the metabolism of anaemia, and he frequently points to the short-sighted impulse to treat anaemia with iron supplementation. This is not only a largely ineffective route to improving the amount and circulation of iron in the blood, he argues, but can affect the production and circulation of haemoglobin that can, in regions where malaria is common, exacerbate this blood-borne illness. Targeting deficient nutrients and not environmental toxicity will throw interdependencies between human biologies and ecological systems out of balance. The challenge, he writes, is to reduce recurrent harmful stimulation to the immune system by addressing environmental damages associated with living in communities that have been forcibly held in toxic poverty. In other words, the 'developmental origins' of malnutrition may be more tightly linked to growing up in toxic environments than to conventional approaches to food security focused on insufficient access to food.

Although Solomons does not write explicitly about racism and sexism in his paper, his conclusion poses challenges for these systems of oppression. When the origins of malnutrition lie in prenatal nutrition, it becomes women – and, especially, Indigenous women who experience Guatemala's highest rates of chronic malnutrition – who are marked as deficient and targeted for supplementation. Similarly, when the problem of malnutrition lies in what people are eating, it is women's expertise that is undermined, given that they primarily run their families' kitchens. In contrast, when malnutrition becomes understood as originating in toxic water and sanitation systems, the burden of treatment might shift to governments, who have the responsibility to provide healthy infrastructures.

### 24.3.3 Care for the Context

In the years since the publication of the dirty chicken hypothesis, Solomons' critique of nutrient-based development interventions has grown more pronounced [17, 18]. He wants his colleagues in nutrition and public health to see human growth as an adaptive and ecologically interdependent process of development. Human growth on its own is not an obvious or intrinsic good, he argues; environments must also be conducive to this growth. As he explains, in an article titled 'Environmental Contamination and Chronic Inflammation Influence Human Growth Potential',

[P]ushing dietary interventions to achieve faster growth in the absence of other measures to improve living conditions could prove to be futile (and expensive), counterproductive (and dangerous) or both, depending upon the specifics of ethnicity, climate, cultural practices and human ecology in a given underprivileged setting [18].

The resultant argument is that along with care for diet, the public health community must care about environmental antigens, including toxicities and contamination that impede growth, and cultural and political systems that shape urban planning and family planning alike.

Solomons critiqued a narrow understanding of development that pushed mothers and babies to grow larger while ignoring the environments in which they lived, including not only questions of hygiene but also questions of whether women birthed with midwives or in hospital settings, and whether there were resources to support obstructed labour. He was particularly concerned that the field of public health nutrition's goal of



producing large babies, and its reliance on prenatal supplemental nutrition as a means of achieving this goal, would set up conditions of obstetric violence, increasing rates of maternal and child mortality. The implication, building upon Scrimshaw's long-standing interest in the interdependence of bioecological systems, was that the public health and development communities should direct more attention 'to the material environment than to the infant/toddler diet' [15]. As Solomons had earlier written, 'Such a comprehensive public health approach should permit children to be bigger under environmental circumstances in which becoming bigger is truly better' [18].

## 24.4 Conclusion

In this chapter, we have asked how the field of global development might change by adopting models for DOHaD that emphasise how human ontogeny is interdependent on social and ecological conditions. In our two cases, scientists in Bhutan and Guatemala concern themselves with how relational and systemic interactions shape child development. In the Bhutanese case, Deki Pem observes that maternal and child nutrition, substance abuse, intergenerational eldercare, and environmental toxicities might also be interdependently addressed in DOHaD interventions. Caring for one input of the 'fishbone' while neglecting others makes little sense, since they all contribute to the child's development. In the Guatemala case, interdisciplinary interest in the immunological impact on metabolic processes leads scientists to advocate for the importance of addressing environmental contamination. While the cases differ in their historical and cultural specificities, the scientists in Bhutan and Guatemala both argue that equating nutrition primarily with nutrients misses out on the dynamic, systemic interdependencies that give shape to development.

To be sure, biological models of interdependent ontogeny pose their own challenges. Solomons found the science of ontogeny inspiring because it shifted attention away from how mothers cooked and what they ate and towards environmental contaminants, ranging from microbes to chemical pollutants. In practice, however, a focus on ontogeny can risk cementing the notion that mothers are responsible for the future development of their children [19, 20]. Natali Valdez illustrates how theories of the interdependency of development that might inspire policymakers to act capaciously become foreclosed by reductionist – and frequently racist and sexist – policy imperatives [21]. For example, in *The Lancet's* hierarchical modelling, development may depend on a great many factors, but it's the mother's behaviours (what and how she eats) that matter most. This model risks reinstating the oppressive mother-focused interventions that some DOHaD scientists wielding models of interdependent growth endeavoured to overcome.

Although interdependence is not a virtue in its own right, we have shown how scientific analyses of interdependent ontogeny from Guatemala and Bhutan can offer a pathway for reworking development interventions. Amber Benezra, in her research on nutrition science, points to the need for policymakers to recognise how they are engaging with interdependent, intergenerational, interdisciplinary, interactive, and intersectional processes [22]. We have likewise described a pathway for conceptualising development through selectively unfolding relations. Rather than understand development as hierarchical, teleological, or following a pre-programmed trajectory, we might rather see the development of the child as part of an adaptive ecological system that coalitions of actors can work to shape. Politics, culture, and environments must all be cared for together.

Expanding the conceptual vocabulary surrounding development to think of ontogeny as an interdependent process helps to cultivate new possibilities for health intervention, inspiring what Hannah Landecker has described as ‘different biologies than otherwise would have existed’ [23, p. 149]. *The Lancet*’s hierarchical and linear models of development encourage health policymakers to focus primarily on malnutrition’s most proximate causes. Taking a page from the sciences of ontogeny in Bhutan and Guatemala, however, may help inspire policymakers to consider that which appears neither immediate nor urgent, but which nonetheless has a structuring influence on global development and human health alike. They might prioritise, for example, the virtue of a clean water system (see also Roberts in this volume). When water is clear, affordable, and contaminant-free, its flow can allow an entire community to flourish. When it comes to implementing health interventions, policymakers might ask if these interventions attenuate stress and build strong communities. Is the land people live in on safe, and do they have sovereignty over this land? Are people encouraged to engage in political and social advocacy and taught how to organise themselves to refuse sources of hunger and exploitation? A lesson from the tendrel fishbone model and the dirty chicken hypothesis is that DOHaD-informed child development policies must look far beyond the child, caring not just for the nutrients this child eats but for its relations. The questions are at once scientific and political: how do we strengthen those relations that are nourishing and detach from those that further toxicity?

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