Embodiment is Ecological:

The Metabolic Lives of Whey Protein Powder

Abstract

This article explores the metabolic lives of whey powder, the most popular form of protein supplement in what has become a multibillion-dollar industry during the past two decades. Faced with the slippery and elusive properties latent to this multiplicitous substance, our approach is to follow whey powder from its mid-twentieth century emergence as a noxious byproduct of industrial dairy production, through the human and animal bodies unevenly tasked with its processing, and out into waterways, where its nitrogen density rematerializes as a pollutant. We show how whey powder emerged as a solution to the environmental damage posed by whey pollution, how such damage is an effect of the systematic overproduction endemic to agrofood industries, and how whey's toxicity persists through processes of metabolism and consumption, despite attempts to process and profit from its vital capacities. Throughout, we argue that whey exemplifies ecological embodiment, understood as the co-constitutive relations between bodily matter and ecological life, and their entanglement with processes of commodification.

Seven Keywords: Dairy, Embodiment, Environment, Metabolism, Multispecies, Nitrogen, Protein

Introduction

This article arose from our discovery that whey protein powder, an increasingly prevalent ingredient in twenty-first century diets, is derived from dairy industry effluent (Marwaha and Kennedy, 1988). Those huge plastic tubs of chalky residue that line store shelves and infuse all manner of health and fitness supplements are, it transpires,

descended from a nitrogen-rich, noxious byproduct of milk and cheese production. The bodies of well-fed gym patrons, malnourished or otherwise 'at risk' patients, and followers of dietary trends have become conduits for repurposed toxic waste. Even consumers not intentionally seeking whey supplementation might be surprised by its appearance in products ranging from potato chips to beer. How, we asked, has dairy effluvium become central to a $7.9 billion global protein powder industry (Business Wire, 2019)?

This initial revelation and corollary questions have since propelled us across bodily and disciplinary borders in pursuit of whey protein. What began with a shared curiosity as to how this substance had transcended its niche appeal in bodybuilding subcultures (Atkinson, 2007) became an interest in the 'more-than-human' (Braun, 2005; Whatmore, 2006) embodiment of whey protein that has taken us out onto industrial dairy farms, through high street stores and kitchen cabinets stocked with whey powder, into the messy processes of human digestion, and out, by means of excretion, into wastewater systems. Along the way, we have been impelled to consider connections among the contradictory 'binge and purge' logic of 'agrofood capitalism' (Guthman, 2015: 2523), the uneven socioeconomic contexts in which nutritional supplements are manufactured and then marketed as vital for health (Abrahamsson, Bertoni, Mol and Ibáñez Martín, 2015), the slippery cultural distinction between where food stops and waste begins (Coles and Hallett, 2013; Evans, Campbell and Murcott, 2013), the multispecies composition of 'human' embodiment (Haraway, 2007; Kirskey and Helmreich, 2010), the 'biocultural' and creative character of proteins (Frost, 2016; Myers, 2015), and political ecological relations between bodies and health (Guthman, 2012; Guthman and Mansfield, 2012).

Our attempt to follow whey on this convoluted journey through bodies of flesh, water, and knowledge forms the focus of this essay. We set out to trace how and with what

effects noxious dairy effluent is rematerialized into profitable nutritional supplements, which are in turn metabolized into muscle or fat, or into new forms of detritus as excess protein leaves the body. Our attendant aim is to use whey's metamorphoses to theorize a more general elusiveness, indeterminacy, and earthiness of corporeal composition--what we call 'ecological embodiment.' In this rendering, the diverse more-than-human affiliations that constitute 'the body' are inevitably entangled with commodity relations in ways that strengthen some bodies and compromise others.

Our travels with whey have been aided by kindred literature that follows things through places, divisions of labour, social relations, more-than-human actor-networks, and other material-discursive webs (e.g. Appadurai, 1986; Latour, 2005; Marx, 1992; Mol, 2002). Arjun Appadurai's insight that 'all things are congealed moments in a longer social trajectory' (2006: 15) has proven especially useful when infused with a method that opens up the social to include the ecological, multispecies trajectories along which stuff such as whey travels. In turn, scholarship on the fluid boundaries that separate *food*--the 'thing that is caught up in the process of being eaten' (Roe, 2006: 112)--from *food stuff*--the material 'before it becomes engaged in the actual process of eating' (Roe, 2006: 112)--from *waste*—'matter that has crossed a contingent cultural line that separates it from stuff that is worth keeping' (Watson, 2013: 244) has helped sensitize us to the messy distinctions between whey's multiplicitous forms (Hawkins, 2006; Ibáñez Martín and de Laet, 2018). Registering how whey's composition and value are variously determined or in flux has also challenged us to ask, alongside Claire Waterton and Katherine Yusoff, 'how to think that which is not (and perhaps will never quite be) a thing, a body' (2017: 4). While this question is not easily answered, where the temptation has arisen to isolate or contain whey in a particular place, scene, or form, we have sought to conceptualise this complex substance as an ongoing,

'contentious synthesis' of humans and non-humans, of 'bodies becoming other bodies,' and thus, in Eric Sarmiento's words, a point of departure for questions of 'embodiment, relationality, power, and collective becomings' (Sarmiento, 2013: 74).

In this respect, our arguments build on insights that have recently gained traction in body studies and related fields concerned with the complexity of body-health-environment relations, notably critical food studies and political ecology (Guthman, Broad, Klein and Landecker, 2014; Landecker, 2011), the ethics and geographies of waste (Hawkins, 2006; Ibáñez Martín and de Laet, 2018), and 'new' materialist and posthumanist philosophies of the body (Alaimo, 2010; Frost, 2016), food (Abbots, 2017), and ecology (Bennett, 2010). While claims to the sovereignty of the body have long been disputed by social and cultural analysts, and have never taken hold in many Indigenous and non-western cosmologies and worldviews (Belcourt, 2015; Sundberg, 2013), the materiality of embodied practices is increasingly being conceptualised as biosocial (Blackman, 2016; Landecker, 2016; Meloni, Williams, and Martin, 2016), socioecological (Guthman, 2015), and more-than-human (Braun, 2005; Whatmore, 2006), or through other neologisms intended to evade, complicate and recast nature-society dualisms. Our contribution is to emphasize how an everyday fitness practice, such as the ingestion of a post-workout shake or other protein-infused product, is entangled with dispersed and often injurious infrastructures. Attending to the biological, technological, and economic resources enlisted to realize the metabolic potential of a recalcitrant corporeal substance highlights how ecological bodies are differentially incorporated into processes of commodification, and how they can exceed attempts to tame their vital capacities.

In what follows, we consider the ecology of whey across three scenes, the first of which begins in post-war North America. Here, we offer an account of the movement of

whey effluent from 'gutter to gold' (Smithers, 2008): from rivers, streams and sewers to smoothies, snacks and blenders. In this scene, the polluting propensities of whey, governmental regulation, techno-scientific innovation, and capitalist logics of growth and renewal cohere in the making of a protein powder market. Next, we focus on the enlistment and exploitation of multispecies labour in the coproduction of whey powder. Specific attention is afforded to how human and nonhuman animal bodies are differentially put to work in a dairy industry seeking to 'fix' the environmental problems posed by whey. Finally, we follow whey in and then 'out' of human and animal bodies into wastewater systems. The focus here is on the contingency of digestive processes and the residual toxicity of nitrogen-rich urea once excreted. Nitrogen pollution is an under-represented environmental issue, one that returns us to matters of (over) production in which whey waste, dairy and other aspects of agribusiness are implicated. Throughout, we highlight the use of both human and nonhuman bodies to commodify whey effluent, and the unremitting environmental problems arising from widespread protein consumption, as exemplary of ecological embodiment.

From Gutter to Gold: The Commodification of Whey Waste

To what are we referring when we speak of whey? In technical terms, whey is the liquid that remains from milk and cheese production. This definition represents only one moment in whey's reiterative 'transcorporeal' journey (Alaimo, 2010), however, one that is outmoded once whey leaves that particular context. Indeed, the whey that came to our attention and prompted this analysis was something quite different: a dehydrated nutritional supplement endowed with various biochemical capacities once purchased, consumed, and metabolized. Such multiplicity persists across the overlapping scientific and

industry literatures that form our archive in this work, where whey is variously designated as a chemical compound, a string of amino acids, an energy source, an aid for weight management, a by-product of dairy manufacturing, a harmful pollutant, a type of bovine biocapital, a technoscientific environmental solution, an expression of physical capital manifest as muscularity and vitality, or just a simple scoop of powder.

The birth of the protein powder industry can be traced to the rapid industrialization of agriculture that occurred in the post-World War II era. New breeding and feeding practices allowed for the year-round production of milk, thus generating the need for a bigger market for the yields that resulted. Human consumption of cow's milk reached its peak in the United States during World War II (Wiley, 2014), and has declined quite sharply in most global north countries over the past thirty years. This drop has occurred for a number of reasons: An expanding discourse that frames milk as nutritious for calves but hard to digest and nutritionally unnecessary for humans, especially those who have an increasing variety of protein sources (including plant-based milks) available to them; widespread concern about the health effects of hormones fed to animals and then ingested by the humans who eat them; and animal rights advocacy that challenges the mass incarceration, torture, and slaughter of cows in the factory farming system. A decades-long public health campaign to persuade people to eat less saturated fat adds another layer to this story, as producers have had to find a home for the huge surplus of whole milk and milk fat that has resulted (Moss, 2010).

Thanks in no small part to the marketing strategies of Dairy Management, an arm of the U.S. Department of Agriculture whose mission is to 'build demand for dairy products,' milk surpluses have been slipped back into North American diets—primarily and paradoxically—in the form of another saturated fat: cheese (Moss, 2010). The campaign to

encourage people to eat more cheese has been remarkably successful: In 2016 Americans ate an average of 17.46 kg (38.5 lbs) of cheese each year and Canadians 13.46 kg (29.7 lbs), almost triple the amount they consumed in 1970 (Bentley, 2014; Canadian Dairy Commission, 2017; United States Department of Agriculture, 2017). This shift has also been profitable given the higher price commanded by cheese compared with milk (Paxson 2013). While this change in eating habits has helped dairy farmers stay in business, because only 10% of milk can be turned into curds, the move from milk to cheese has generated another side effect: a massive surplus of whey. Nine kilograms of whey remain for every kilogram of cheese produced (Onwulata and Huth, 2009), and a large cheese processing plant can produce over 1 million liters of this protein- and acid-rich substance daily (Jelen 2003). The U.S. dairy industry generated 90.5 billion pounds of whey effluent in 2006 alone (United States Department of Agriculture, 2014).

In earlier eras, at least some excess whey would have been sold to neighbouring farmers for hog or chicken feed or fed back to the pigs that many dairy farmers kept expressly for waste regeneration purposes, practices that some artisanal producers continue to follow (Paxson, 2013). Once industrial production took hold, however, and manufacturing moved off the farm, reuse became an expensive undertaking, requiring diesel-fuelled tankers to haul heat-sensitive whey back to the animals who would consume it. Cheese manufacturers thus began spreading liquid whey on agricultural land, pumping it into municipal sewers, or discarding it in waterways (Lougheed, 2013).

Whey dumping was, by all accounts, environmentally devastating. With its high nitrogen content, whey is one hundred and seventy-five times more potent than untreated human sewage (Smithers, 2008), and came to constitute a major source of water pollution in cheese-making regions like Vermont, Wisconsin and Ontario in the mid-twentieth century

(Crowfoot and Wondolleck, 1990; Knight, 1979; Lougheed, 2013; Menzies, 1994; Scott, 1971). By spurring plant growth and denying aquatic life the oxygen it needed to survive, whey dumping resulted in massive fish kills and contaminated soils (Borre, 2014; Crowfoot and Wondolleck, 1990).

As intensified awareness and activism prompted a wave of environmental legislation across the United States and Canada in the 1970s, governments (Bertin, 1981), cheesemakers (Knight 1979), and food industry researchers (Immen, 1984) urgently sought solutions to the problem of whey waste. Gradual innovations in filtration, separation, concentration and drying techniques made whey processing more efficient and hygienic and the powder that resulted more versatile and palatable (Smithers, 2008). A growing body of nutritional science on whey's 'biological value' (or how quickly and effectively its amino acid content can be biosynthesised) (Hulmi, Lockwood and Stout, 2010), the development of a broader 'nutricentric' culture (Scrinis, 2015), and the concomitant emergence of protein as the über macronutrient of our time provided the marketing impetus necessary to solidify its transformation from a waste product of marginal worth into what corporate researcher Geoffrey Smithers calls 'a valuable dairy stream containing a multitude of components available for exploitation in the agri-food, biotechnology, medical and related markets' (2008: 696). Indeed, the amino acid supplementation market is booming worldwide, with whey protein powder accounting for 83% of online sales in the North American supplement market (Millot, 2016). And, as one might expect, the conversion of whey waste 'from gutter to gold' is narrated by industry insiders as a story of techno-scientific ingenuity, environmental triumph, and commercial success.

The development of protein powder has undoubtedly gone some way to mitigating the problem of toxic whey, and helped the dairy industry match the consumption of milk

with its overproduction—a crucial strategy given the limit to how much people can eat. Julie Guthman's (2015) notion of the socioecological fix is useful here. For Guthman, a fix occurs when the body is enlisted not simply to generate profit, but to overcome limits to accumulation. She illustrates this by pointing to the ways people have been encouraged to consume more calories than they need or to supplement their diets with snacks as a solution to the systematic overproduction of agricultural products. Consumer bodies are reworked in the process—by growing bigger and sometimes fatter ('obesity' research is both highly contested and moralizing)—and 'new rounds of accumulation' are made possible as they then seek solutions to increased weight.

Guthman's work highlights the economic dimensions of contemporary embodiment and, insofar as fixes are never absolute because new problems emerge that are only ever 'partially resolved,' her analysis resonates strongly with our conceptualization of whey (2015: 2523). However, whey's propensity to exceed attempts to profit from its capacities requires that we extend the scope and emphasis of this insight. Guthman uses the term 'ecological' to describe the fix, but her analysis in this article is focused on human biology and not on a human embodiment that incorporates relationships with other living organisms or the 'natural environment.' In building on her ideas, we highlight not only how human bodies are enlisted to fix the problems posed by excess dairy effluvium, but how whey—as an active ecological agent--eclipses its assigned roles and places new demands on the bodies and industries that seek to alleviate its toxicity and harness its value. Specifically, we see how the "biochemical processes" (Guthman, 2015: 2523) of nonhuman animal bodies are also put to work through whey's commodification, and how the persistent toxicity of whey beyond these processes relates to the problem of nitrogen pollution. In always exceeding reductive biological and consumerist conceptions of protein, whey's

transmogrifying qualities, its dynamic enmeshments with more-than-human worlds, begin to emerge.

Dirty, Difficult, and Dangerous: Whey Production and Multispecies Labour

Cows are perennial labourers in industrial animal farms, a fact that Big Dairy has selectively acknowledged and concealed in line with its own objectives:

> Privately, the dairy industry has always recognized and understood this. Whether in their academic textbooks, training manuals, or internal analyses, they consider the actions of the cow to be a form of work. Whether in their economic theory, management strategies, or operational practices, cows are thought of, described, and treated as unwaged employees and workers. Publicly, however, this labor has been devalued, dematerialized, and made invisible. It has been hidden under the guise of 'natural.' (Hribal, 2007: 2)

This naturalized, embodied—and gruelling—labour is central to the value dairy cows create, just as it is for their human co-workers. The brutal and well-documented conditions in which industrial agricultural cows toil, the immense physical and psychic suffering connected to their separation from their calves within a day or two of birth, their subjection to a near-year-round regime of concurrent pregnancy and lactation, and their maiming and confinement, illustrate all too vividly that 'capitalism is hard on bodies' (Guthman, 2015: 2527). That the 'dirty, difficult and sometimes dangerous' dairy industry relies on precarious and usually racialized and migrant labourers to handle these cows, and to endure the kicking, charging, and trampling cows engage in as they resist their captivity and status as property, underlines the multispecies character of bodily denigration (Sorrentino, 2014: no page online source; Douphrate et al, 2013). The decidedly sterile, incorporeal appearance of

desiccated whey and its 'disappearance' into energy-boosting supplements belies that it is living beings, under the duress of the factory farms that employ them, whose bodies and bodily secretions make protein powder possible.

But to consider the body as a socioecological fix means moving beyond the means by which human and non-human animal bodies absorb the externalities of capitalism, and even beyond the identification of the body as an accumulation strategy through enclosure and ownership, an undoubtedly useful analytic for thinking about factory-farmed animals (Guthman, 2015; Harvey and Haraway, 1995). Instead, attending to the fix entails a consideration of how bodies are opened up as new sites for the 'circulation, production, and absorption of capital in an ongoing'--and we would add, *metabolic* and *iterative*—'way' (Guthman, 2015: 2527). For 'a socioecological fix,' according to Guthman, 'is at work when bodies become integral to the *circulation* of capital: when, for instance, they absorb surplus production or when bodily processes become sites of capital investment, particularly in relation to a specific limit or crisis' (2015: 2527). It bears emphasis that as cows help satiate human appetites and animate human body projects, they also work as consumers in the service of waste management, for the very whey effluent they help produce is a major source of cow (and other animal) feed. Both senses of the fix are at work here: Cows and humans absorb whey powder in its materialization as a fix for the systemic overproduction of milk that is integral to North American agricultural industries (Cochrane, 1993; Guthman, 2015; Winders, 2012). And their bodies (and those of numerous laboratory animals no doubt) become sites of investment for industry-sponsored researchers attempting to find ways to offset the environmental crisis posed by whey pollution or to demonstrate the health benefits of higher protein diets. For those humans for whom such protein-waste is surplus to their nutritional needs (i.e., most humans in the industrialized West), it can be

converted into other forms of capital such as improved health, anti-ageing aesthetics, and musculature. For cows, meanwhile, incarceration, rather than health promotion, ensures the reiterative biosynthesis of their own surplus whey.

It is important to note that the differential incorporation of whey along multispecies lines is not the outcome of capitalist production alone. Billy-Ray Belcourt (2015) reminds us that domesticated animals such as dairy cows are not just capitalist workers, but colonial subjects. The insertion of captive animal bodies into spaces from which Indigenous bodies have been forcibly displaced represents a longstanding and ongoing tactic of settler colonialism. Dairy cows, who are 'always already scheduled for death' (Belcourt, 2015: 9), replenish the labour power or physical capital of the settler state and its subjects. They also contribute to the contamination of those Indigenous lands and waters that are not appropriated by big agriculture, for not all waste, whey or otherwise, is diverted. And, in helping satiate settler appetites and animate their body projects, they participate in a 'contentious' synthesis of humans and non-humans (Sarmiento, 2013: 74): A violent entanglement that sharply undermines notions of bodily autonomy or nutritional choice given that cows are enlisted in the production and consumption of whey as 'fixes' for the crises of production in settler-colonial societies, for the contrived demand for protein-heavy diets, and for protein-related pollution.

Fixes are always contested, of course, and human and cow consumption of whey are no exceptions. Occasional questions are raised about the efficacy (Frankel, 2017) and safety (Consumer Reports, 2010) of whey powder in terms of human consumption of protein. Indeed, there is little consensus among nutritionists, exercise physiologists, nephrologists, bodybuilders and others about precisely how much, what type, and when human animals—serious athletes or otherwise--should ingest protein (a debate that is mirrored among

animal nutritionists) (Jäger et al, 2017; Wolfe, 2008). Nor is there agreement on the most reliable method by which to determine and measure optimal consumption across the diversity of human bodies (Millward, 2012). What does seem well established is that protein malnutrition in the industrialized West is extremely rare (Fulgoni, 2008; Institute of Medicine, 2002). We also know that some research shows an excess intake of amino acids to be correlated with kidney and liver disorders, increased cancer risk and heart disease, and bone and calcium homeostasis (Delimaris, 2013), though such findings are hotly contested within nutrition and exercise circles (Bilsborough and Mann, 2006; Churchwood-Venne, Burd, and Phillips, 2012; Devries and Phillips, 2015) where the promotion of protein intake above the current recommendations, especially for older adults, is gathering steam. In popular media, concerns about protein overconsumption are commonly focused on the possibility of unintended weight gain or the adverse effects of failing to match protein ingestion with appropriate amounts of exercise and energy expenditure (Beck, 2017). Rarely is consideration afforded to the effects of protein consumption as these might exceed individual biological systems, or to the ecological implications of increased protein consumption en masse. These implications reassemble, though, as we continue to follow whey on its metabolic travels in, through, and out of the bodies of those who consume it.

Recalcitrant in Nature: Ingestion, Metabolism, and Nitrogenous Waste

To recap: We find in the post-war history of whey protein in North America not an originary cultural demand for more protein being met with greater production, nor the profit imperative and consumer culture ascending without a hitch. Rather, we find bodies being unevenly enlisted to recycle a once-toxic byproduct of industrial dairy production with, as we shall continue to see, inconsistent results. This is a more distributed

achievement than Big Dairy might acknowledge in its celebrations of whey's commodification, but it is nonetheless held up as an achievement of sorts. By focusing on multispecies labour, we have sought to show the differential incorporation of bodies into this 'fix', and to signal some of the implications for dairy cows enlisted in this process. But what of 'human' bodies? What happens when consumers sip on a smoothie or ingest some other whey-infused product, and metabolize the product of all this activity?

This process, too, is more contingent than one might expect. It matters who is consuming whey, where and when; it matters if they are eating it in liquid, bar, or pudding form; and it matters whether this whey is a desiccated product of industrial manufacture or the remains of coagulated goat's milk. Such contingencies, however, are hard to hold on to once food is ingested. Here, following whey means drawing on the language and knowledges of nutritional science (Gropper and Smith, 2017) in pursuit of 'what happens' when whey is out of sight (Mol, 2008), but doing so with the assumption that the subject of consumption is never 'just' a human body, singular or sovereign. Annemarie Mol's analysis of eating an apple helpfully draws attention to the difficulties of accessing the inner workings of the digestive body, but also the complex subjectivities engaged in digestion. The eating self 'does not control 'its' body at all' (2008: 30), she claims, since without food to ingest, there is no 'I.' Moreover, as soon as we chew on an apple, we become made of it; it becomes part of us. Given that 'a person cannot train the internal linings of her bowels in a way that begins to resemble the training of her muscles,' we may eat many whey protein bars, but 'we will never master which of their sugars, minerals, vitamins, fibres are absorbed; and which others [we] discard' (Mol, 2008: 30). While Mol is primarily concerned with 'how to give words to this mode of being a subject' (2008: 30), we emulate here her

desire to emphasize the shared, relational subjectivity--*and embodiment*--of the eater and eaten.

Conventional nutritional knowledge holds that protein metabolism occurs at different speeds depending on a number of factors including the form the substance takes, how quickly the eater chews and swallows, the health of the esophagus, whether or not the food is washed down with a beverage, and the availability of the appropriate enzymes and nutrients in the body. Liquid whey, which does not require mastication, is designed to move swiftly through the digestive tract, hence its appeal to athletes adhering to the idea that post-workout muscle building and repair is aided by immediate supplementation (Devries and Phillips, 2015). The amino acids that constitute protein-rich foods are comprised of varying configurations of carbon, hydrogen, nitrogen, oxygen and, in some instances, sulphur. These compounds, formed into chains of various strengths and sizes, are necessary for survival, but not necessarily in the same combination in which they arrive in the digestive tract. Pepsin enzymes thus go to work to dismantle the bonds that hold the chains of amino acids together so that they can be broken down into functional parts and built up again into new combinations for use in a variety of processes. If all goes according to plan—Samantha Frost (2016) describes such processes as having 'direction without intention'—the polypeptides that result then make their way into the small intestine where pancreatic enzymes join the process, disassembling these newly configured amino acids into even smaller units. From the small intestine, transporter cells deposit amino acids into the bloodstream where they travel to the liver, the hub of protein metabolism in animal bodies. Some of these amino acids are used directly by the liver for protein synthesis, the regular cellular regeneration that sustains the body. Leftover amino acids not required to replace or build new proteins can be converted into glucose or stored as fat; they can also be used to

fuel the construction of new tissue such as muscle. In the process of decomposing or storing amino acids, excess nitrogen forms into toxic ammonium ions that are in turn converted into urea, transported to the kidneys, and, if things go conventionally, eliminated during urination (Gropper and Smith, 2017).

Omitted from this scene are all sorts of matters and their meanings that might make a difference to the efficacy of protein consumption, indeed to whether consumption unfolds at all. The filtration of whey into powders of varying quality, the concomitant ingestion of other foodstuffs, the consumer's exercise routines and movement habits (also, perhaps, forms of labour), and much more besides, have a bearing on how this process unfolds, and how it is situated, socially and historically. Just as bodies are not as predictable in their metabolic processes as nutritional orthodoxy might imply, neither does whey, an indeterminate body of sorts, automatically manifest in an enriched body or indeed simply vanish once 'processed' through digestion and metabolism.

Indeed, it is protein-rich urine, the vehicle for transporting 80% of waste nitrogen out of the body, that is key to understanding why protein powder cannot shake off its persistent ecological entanglements. Stuart Phillips, a prominent figure in research on the impact of nutrition and exercise on human muscle protein turnover, consistently emphasizes that there is a limit to how much protein the body can use (Ledin 2014). Humans are inefficient processors of nitrogen, moreover, and 'a large fraction' of the compound remains post-consumption (Mulder, 2003: 68). Once the body has done what it can with the protein it ingests, this excess nitrogen is, in Phillips' words, 'fundamentally toxic' (Ledin 2014).

According to Jan Erisman, a leading researcher in the science of sustainable agriculture, nitrogen pollution is 'one of the most pressing environmental issues that we

face,' though it receives little attention comparative to carbon and methane in particular (Erisman et al, 2013: 3). It is worth quoting Erisman at length here:

> Numerous, often interlinked, thresholds for human and ecosystem health have been exceeded due to excess nitrogen pollution, including thresholds for drinking water quality (due to nitrates) and air quality (smog, particulate matter, ground-level ozone). Eutrophication of freshwater and coastal ecosystems (dead zones), climate change and stratospheric ozone depletion are also consequences of the human modified N, cycle. Each of these environmental effects can be magnified by a 'nitrogen cascade' whereby a single atom of reactive protein can trigger a sequence of negative environmental impacts through time and space. (Erisman et al, 2013: 3)

It is important to note that human and animal excretion is just one of a multitude of sources of anthropogenic nitrogen pollution. Synthetic nitrogen fertilizer, which acidifies soils and leaches into drinking water, rivers and seas, is the major source of reactive nitrogen in the environment. Its global emergence has recently been charted as part of British imperial expansion and governance (Page, 2016), thereby complicating histories that would reduce the proliferation of nitrogen fertitilizers 'to a simple story of triumphant modernity' or economic globalisation (Page, 2016: 385). Clear parallels with the emergence of whey protein can be drawn, not least in the hailing protein as simply pollutant or health elixir, as problem or solution. While the world's population could not be fed without the use of industrially-produced fertilizer, the demand for protein-rich foods has dramatically exacerbated nitrogen pollution. Even before humans consume a protein shake, then, substantial volumes of nitrogen are lost to the environment through the cultivation of feed for the cattle who produce the milk, and yet more are lost in the cows' manure.

Once the shake is digested, the problem is compounded. This is because nitrogen is 'recalcitrant' in nature (Westgate and Park, 2010: 5252) and its removal from wastewater is costly and energy intensive. Multiple methods of urea removal are in development, but in the US, for instance, only 5% of this toxic substance is currently removed (Moran, 2016; Urbanczyk, Sowa and Simka, 2016). Thus, despite a thirty-year effort on the part of the dairy industry to tame its toxic waste by enlisting humans and non-animals in its regeneration, whey's toxicity persists. And, in the process of diverting excess whey and converting it into powder for consumption, waste becomes food, food becomes waste, and protein rematerializes anew.

Metabolic Afterlives: A Conclusion

The conversion of whey effluent from hazardous waste into a multi-billion-dollar industry emphasizes the relentless innovation required by capital to keep the biosphere at work (Moore, 2015). And critical analysis might start and stop at the door of the dairy industry were it not for the refusal of whey to conform to economic and biopolitical projects designed to alleviate its toxicity and harness its value. As whey shifts between effluent and asset, poison and panacea, it places ultimately irreconcilable demands on the biological, ecological, and techno-scientific systems that it inhabits en route. This same tendency makes it difficult to capture whey in a single shape or place, to contain its qualities along a continuum of healthy supplement and hazardous waste. In place of purity and certainty, what we have provided is an exploration into these multispecies travels as evidence of the persistent ecological entanglements of embodied practices.

Our contention is not that whey's commodification and ongoing toxicity undermine bodily innocence and integrity. When we describe whey's manifestation as a toxin, as we did in our introduction, we are pointing to whey's high nitrogen density and the implications

this can have for the bodies of flesh and water that it comes to inhabit. Embodying toxicity, though, is increasingly understood as simply part of living in the twenty-first century, when blood, cells, urine, and other vital fluids and tissues are shown to be 'contaminated' by chemicals that inhabit the water we drink, the food we eat, and the air we breathe (Liboiron, 2016; Murphy, 2017). In this context, bodily purity, long associated with biopolitical projects ranging from eugenics to miscegenation, is not simply fraught, but elusive, and whey's reinvention as a popular nutritional supplement is, in itself, unexceptional (Shotwell, 2016). Rather, we find significance in the historical and social context in which whey powder has emerged as a health and fitness commodity. Noteworthy here is that whey's toxicity proved a catalyst in its commodification, and that whey is not purified of its noxiousness once processed into powder, digested, or excreted; problems related to capitalist production are displaced rather than resolved by whey's commodification and consumption.

Understanding whey as a multiplicitous substance through the entangled processes of commodification, multi-species labour, and the global nitrogen cycle demonstrates that ecological issues have not been allayed since the 'protein boom' created new possibilities for its use and profitability. Whey dumping and its known ecological effects endure: only a fraction of whey is converted into commodity form for human consumption and even this, in turn, becomes the problem of wastewater management engineers faced with filtrating increasingly nitrogen-dense water systems. The rest of the excess is either diverted back into animal feed, or subject to costly ultra-filtration practices before finding its way, eventually, into those same wastewater managements stations. The cultural preoccupation with protein as a fashionable nutrient for multiple and diverse human body projects not only adds to the challenges these engineers face, but also exacerbates the continued

exploitation of dairy cows and human labourers in the dairy industry, and might even be seen as contributing to the alteration of the global nitrogen cycle (Erisman et al, 2013).

That the preoccupation with whey protein was borne, at least in part, from an ecological crisis of milk and cheese production is clearly not historical happenstance. Indeed, the story of whey's conversion 'from gutter to gold' (Smithers, 2008) demonstrates a confluence in the problematizing of whey dumping and the popularising of whey protein, to the point where whey-based functional goods are now heralded as key vehicles for delivering the physiological benefits of protein itself, and have become almost synonymous with human health and nutritional well-being (Ha and Zemel, 2003). While questions remain unanswered about the remarkable rise of protein as the transcendent nutrient of our time, an ethical response would consider the role of the dairy industry in this growth and the implications of whey protein's popularity for the dairy cows from whose bodies it is harvested. For the industry's story of triumph heralds the omnipresence of protein powder as a solution to the problem of whey pollution even as the value that whey now holds helps sustain the predictable reticence of Big Dairy to entertain lower milk output as a solution to this problem. The ecological stakes for addressing overproduction are high: The manufacture and transportation of dairy cattle feed, enteric fermentation, and manure storage and processing combine to produce an estimated 4.6 gigatonnes of carbon dioxide equivalent (CO_2-eq) emissions per year, which amounts to 20% of all agricultural emissions. Attempts to resolve the environmental challenges posed by excess whey through its commodification as protein powder, which as we have seen are far from complete, thus do little to address the broader role of the global dairy industry in climate change, deforestation, biodiversity loss, and land, air, and water pollution (Food and Agricultural Organization of the United Nations, 2006). Put differently, whey powder is a solution to

environmental damage, but such damage is an effect of the systematic overproduction endemic to agrofood industries and entails ecological consequences that far exceed whey pollution.

In the meantime, protein pollution represents a huge challenge, the costs of which are unevenly distributed across institutions, bodies, and species. Yet, stories of both environmental triumph and defeat over simplify the healthy and hazardous potential of whey. It is whey's propensity to exceed its assigned forms and roles that led us to explore the complex, reiterative process in which it travels and mutates through biological and ecological systems, creating surpluses and deficits of value and waste, and strengthening some bodies while compromising others.

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