Environment and Planning D: Society and Space 2007, volume 25, pages 967 – 989

DOI:10.1068/d74j

Laboratories, laws, and the career of a commodity

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Received 4 August 2005; in revised form 29 May 2006

Abstract. Unlike most foods, milk is produced fresh at least twice every day, thus recreating, over 700 times a year, a commodity 'designed' by the combination of nature, commerce, and law. The paper is a study of the ontogenesis of this commodity in Britain since 1800, stressing the emergence of two new objectivities: dairy science and the law on adulteration. In the words of Christopher Hamlin, what mattered was the "manufacture of certainty, however flimsy that certainty might later be shown to be." This was achieved by the collection of samples, the generation of facts by the deployment of the laboratory technologies of physics and chemistry, and a semimonopoly over the truth-power of dairy science that was gradually built up by the large commercial companies. A foundation of state-sponsored regulation provided an official legitimation of compositional standards that suited the interests of capital but ignored 'natural' variations in quality and often pilloried innocent producers. The public eventually became accustomed to the regulated quality of the milk in its 'pinta' and assumed it to be natural. Even the standardization of composition since 1993 has caused very little disquiet among the consuming public, although milk is now a fully constructed commodity like any other dairy product. Mechanical modernity has at last triumphed over a century of 'milk as it came from the cow'.

Introduction

"Knowledge always lacks. Ambiguity always lurks."

Douglas (1992, page 9)

The rematerialization of social science is well under way, on the premise that matter does matter (Bakker and Bridge, 2006; Saldanha, 2006), although within this surge of literature it could perhaps be argued that 'materiality' as a concept is in danger of losing its coherence. Studies are now multiplying across a spectrum ranging from objects-in-themselves, through the objectification of social relations, to embodied materialities, and further on to the relational ontology of writers on posthumanism and technonatures.

All of these approaches and more, some inspired by foundational interventions from Jackson (2000), Miller (1987; 1998; 2005), and Philo (2000), have been deployed in the field of food geographies, the territory of the present paper. Whatmore's (2002, page 123) complaint that *matter* per se remains an "absent presence" in much agrifood work no longer seems fair. Mansfield, for instance, has set out to address the neglect of the material of production by stressing the biophysicality in food geographies, in her case of artificial crab and catfish in the United States (2003a; 2003b), and Cook has persistently argued the case for considering the materiality of food in postcolonial geographies (Cook, 2004; Cook and Harrison, 2003; but see Goss, 2006). Roe has worked on the processual emergence of the material qualities of foods, in other words "the process of some *thing* becoming food" (Roe, 2006, page 465, emphasis as in original) and "the *doing* of eating" (page 470), and Bryant and Goodman (2004) propose a 'political ecology' of consumption that relies heavily upon insights from the study of material culture. Stassart and Whatmore (2003) use material semiotics to focus on the risky nature of food by examining the metabolic intimacies between the

bodies of beef cattle and human bodies, and Whatmore herself has famously attempted to "resituate consumption in more visceral terms" by stressing the "tropic quality" of foodstuffs (2002, page 117 – 118), as part of a wider project on hybrid geographies and the reevaluation of agency (Hinchliffe and Whatmore, 2006; Hinchliffe et al, 2005). Here she shares a concern for 'ontological politics' with Mol (1999), who asserts that "ontology is not given in the order of things ... instead, ontologies are brought into being, sustained, or allowed to wither away in common, day-to-day, sociomaterial practices" (2002, page 6). A major contribution of Mol's work is its emphasis of the fragility of object identity because "matter isn't as solid and durable as it sometimes appears" (Law and Mol, 1995, page 291), and she shows that her radical, empirical 'praxiographies' are equally as applicable to food as they are to disease (Harbers et al, 2002; Mol and Mesman, 1996).

Materiality has also become an important consideration in recent writing on food as commodity, ranging from studies of objects in commodity chains to "the social life of things" (Appadurai, 1986; Hughes and Reimer, 2004; Thrift, 2000; Watts, 1998). This work has served a number of purposes, including the illustration, in new ways, of classic concepts—such as spatial circulation—and the launching of new ideas—for instance, seeing objects as constitutive of networks and as worthy of their own biographies (Bridge and Smith, 2003; Cook, 2004; Cook and Crang, 1996; Cook et al, 1998). But there is more to do. Castree (2004) suggests that the literature has been weak on definitions of the commodities it discusses, along with understandings of their changing states. Commodities have, in his view, become floating signifiers without general agreement on how they should be characterized. This is partly because the processes of commodification are slippery in terms of the emergence of cultural, economic, and political valuation and how commodities are enacted in consumption (Goss, 2004). But Castree also implies the use of undisclosed and uncritical conceptualizations.

One possible answer to Castree's challenge of defining commodities is to do so through ontogenetics. This would sidestep Jackson's (1999, page 96) definition of commodities as "objects of economic value ... that are intended for exchange" and return to the more fundamental issue of the emergence of objects and their "brute physicality" (Probyn, 1999, page 216). I should state at the outset that, although the present paper provides a new way of looking at commodities, I am not seeking explicitly to critique either the poststructural turn away from the 'ontological hygiene' of the Enlightenment (Demeritt, 2005, page 820) or Goodman's (2001) very proper claim that 'ontology matters' in agrofood studies (see also Gellert, 2005). I draw inspiration, rather, from the concerns of materialist ontogenesis, starting with the recognition that "each substance is a bearer of change" (Smith and Brogaard, 2003, page 47). This statement provides a philosophical basis in logic for the use of biomedical ontologies in the identification of the point when a growing embryo can be called human. Smith, the leader of this project, has worked extensively on social and biomedical ontologies, and also on the formal ontology of Hesserl, which amounts to a general theory of objects (Smith and Smith, 1995). Another ontogenetic tradition, and one that has recently been attracting much attention in anglophone social science (Dodge and Kitchin, 2005; Massumi, 2002; Stengers, 2005; Thrift, 2005) is that of Simondon (1964). He was a theorist of technology and a philosopher of individuation who argued that objects are best seen through their comings into being (Barthélémy, 2005; Chabot, 2003; Combes, 1999; Toscano, 2006). According to Simondon, the 'ultimate phenomenon' is an assemblage of individuation and individual in which the material object we observe is only one of its phases, the most recent (de Beistegui,

2005, page 118). The successive stages of individuation are accomplished by a process of transduction (Mackenzie, 2002): the ontogenetic repetition or modification of form.

Building upon this last sense of the ontology of temporal mutability, I propose in the present paper an ontogenetics of a commodity by looking at its career path over more than a century. My specific interest is in an important item in the British diet, liquid milk. I will look at the ontogenesis of its modern definitions, drawing first upon changing notions of its 'natural', essential qualities; second, upon the role of chemical investigations of the constituents of milk; and, third, upon how certain sociocultural values were imprinted on milk as a commodity, legitimated through both commercial practices and attempts by the state to impose legal standards.

The present paper, then, is about defining and policing the boundaries of food quality using the moral authority of nature (Daston and Vidal, 2004). It addresses the means by which cow's milk has been manipulated in its composition over a period of two hundred years, from 1800 to the present. Although naturalized to the point of being taken for granted, this organic fluid in reality has been a coeval participant and powerfully influential in the scientific, commercial, and political interests that have emerged to shape the modern food system. Building an understanding of such commodities helps us grasp our mutually constituting relationship with food, which is among our immanent and most intimate contacts with nature.

The paper begins with a brief history of milk as a good and as a bad. This is followed by a history of the 'knowing' of this commodity through facticity, which sets the foundations for a section on the 'economy of qualities' that was the milk food system. Part of this will be a discussion of the influence of the technologies and methods of laboratory-based dairy science, a surprisingly contested field, and of the official enquiries that were mounted into the composition of milk. Finally, the normative impacts of law and governance will be reviewed in the light of their solidification and of the naturalization of new ideas about comodification. There is unfortunately no room in this paper to develop the animality of milk production, although this must feature in future, fuller historical accounts of dairy food systems (see Risan, 2005).

Trust in commodities: the good, the bad, and the hybrid

> "Taming a commodity to make it congenial to the needs of a branch of state administration took (and takes) a great deal of subtle manoeuvring."
>
> Ashworth (2001, page 42)

This paper is an account of awkward histories. It essence is incoherence and contestation in the milk industry, with consequences for the substantial portion of the population who were the consumers of its products. Much of the inconsistency was due to clashes of interests among the various stakeholders, whose multiple perspectives on what milk was, and what it ought to be, created tensions. In short, if your ontology is different from mine, there are many means by which I may attempt an imposition to suit my long-term interests. This may include defining and redefining even primitive certainties such as milk.

In order to build an understanding of emerging views of milk quality, let us begin with a brief history of public perceptions of this commodity as (un)natural. Porter (1998, page 13) complains that the literature on Victorian environmental concepts is scarce: "British historians have paid little attention to the dynamic interactions between environmental change and human institutional and cultural patterns." This assertion seems peculiar in view of the many studies of the work of sanitarians such as Edwin Chadwick and John Simon, especially those recently cast in the Foucaultian conceptual mould (Hamlin, 1998; Joyce, 2003). But it is true that theoretical work on

19th-century food history has rarely addressed the 'environmental'. It may, therefore, be helpful to sketch three dimensions of thought since 1800 that represent: first, milk as natural, as life-giving; second, milk as dangerous due to human intervention; and, third, milk as socionatural hybrid.

Milk, literally as a 'good', is one of those rare commodities that have a virtually universal currency. It has religious significance for Hindus, and in the Western tradition it has also been highly valued. Its somatic connexion with the breast and with motherhood and its iconic whiteness are all crucial, and its pseudo-sacred quality is derived from the goddess theme of nature (Macnaghten and Urry, 1998). As Park (2004) points out, nature as a lactating woman, sprinkling milk on the earth for nurture and fertility, was first depicted in Naples in the 1470s. Down to the present day, ideas of milk's naturalness and innate goodness have proved difficult to shake, despite a recently negative press on dairy nutrition (Cohen, 1998; DuPuis, 2002; Oski, 1992). Partly, this derives from the broad spectrum of vitamins and other nutritional benefits discovered in the 1910s and 1920s. The Advisory Committee on Nutrition, for instance, in 1937 declared milk to be "a food which contains all the materials necessary for growth and maintenance of life" (Ministry of Health, 1937, page 35) but, given the natural variations of the constituents of milk and their manipulation, this was a promise that had not always been fulfilled in the preceding one hundred years. Their statement was a form of product idealism that values commodity characteristics in a symbolic mode and ignores the messiness of everyday discrepancies, but it was also focused on the then emerging properties of milk, one of the foods that benefited most from the innovative science of the 'newer nutrition'.

Much of the positive image of milk in 20th-century Britain also came from the long-term and concerted advertising campaigns of the National Milk Publicity Council (NMPC) (1920), the Milk Marketing Board (1933) and their successors. The NMPC, in particular, mounted a pioneering campaign in the early days of mass advertising, and the public's familiarity with milk was significantly broadened by its support for school milk in the 1920s and 1930s (Atkins, 2005).

The second dimension is less positive and prevailed in the late 19th and early 20th centuries. Here, milk was seen as a problem, as a threat to human welfare rather than as a good This arose from a discourse framing Victorian ideas of 'nature damaged', driven by the public's fear of dirt, pollution, and disease and by what John Ruskin (1903, page 411) called "our loss of fellowship with nature". Stallybrass and White (1986, page 135) argue that the notions of 'contagion' and 'contamination' became the tropes through which city life was 'apprehended', and the Victorians' postromantic view of nature was certainly gloomy (Worster, 1994, page 126). Within this discourse of 'dangerousness', there were subthemes of, first, the urban depression of perceived links between dirt and disease and, later, Darwin's constitutive notions of violence, cruelty, and suffering in the natural world. In order to clean the Augean stables of urban filth and introduce preventative medicine, the city was sewered, drained, and gradually purged of most forms of raw-food production. This last action meant the loss of 'local food'; where previously urban dwellers had known their local milk producer-retailer, this nutritional umbilical cord came to be severed as cow-keepers and small livestock-keepers were banished from the now denatured city. Ironically, there was, as a result, an increased promiscuity in the consumption of produce from distant, anonymous, and possibly dirty or diseased animals. Giddens (1990, page 26) argues that such separation of space, place, and time under the conditions of modernity was a test of trust in anonymous producers and intermediaries, the 'abstract others'. This trust was fragile and was increasingly underwritten by expert knowledges of commodity control (Lupton, 1999).

The Victorians and Edwardians could justify such formal and informal urban planning to themselves on many grounds, including the moral. They espoused ordered values whose enforcement required definitions in law, observation and measurement, and bureaucratic regulation. Their moral repugnance for food adulteration, for instance, engendered a state engine of surveillance and suppression, built on professional skills, that was remarkably successful given the relatively modest technologies at their disposal. Interestingly, the moral discourse was not at all concerned with injustice in prosecuting possibly innocent traders, although this did become prominent in the first three decades of the 20th century, when the moral indignation of the state was exhausted and the reactive voices of commercial actors came to the fore.

What happened to milk at the end of the 19th century was in the realms of what Bakhtin (1984, page 19) called 'grotesque realism'. There was a bizarre reversal away from milk as semisacred in nature, the life-giving fluid with its immunity-imparting properties passed to infants via the comfort and generosity of the mother's breast (Diprose, 2002; Shaw, 2003), towards milk as an animal excretion that was treated with suspicion—in effect, as a dilute poison. Increasingly fed by busy working mothers to their vulnerable offspring, it was the same liquid in appearance but now a bestial caricature of the humane original. It was thought, in many respects justifiably, to be dirty and diseased, due to poor hygienic conditions in the cowshed, lack of care by dealers, and the suspect mediation of retailers.

Cleaning up the milk supply chain was a slow process but there is evidence that hygienists, such as the team of researchers at the National Institute for Research in Dairying, were having a substantial impact by the later 1920s; and the introduction of National Milk Testing and Advisory Scheme in the Second World War completed the process. These efforts received general approbation, although there was resistance among the dairy farming community, which was put to greater effort and expense. The alternative approach was to heat-treat milk in order to eliminate any bacteria before the consumer could be harmed, but this also attracted astonishingly high levels of opposition, on the grounds that pasteurization would destroy the 'natural' properties of milk and reduce its nutritive value and other health-giving characteristics (Atkins, 2000; Enticott, 2003a; 2003b). From the right wing in particular, there were warnings about the dangers of excessive processing of foods, with the eugenic consequences of an enfeebled race. There are resonances here with present-day food scares about the diseases passed through the food supply, such as bovine spongiform encephalopathy/Creutzfeldt-Jakob disease, and recent theoretical developments are encouraging us to question the bodily and the metabolic/ethical connectivities between the health/well-being of animals and their flesh as it enters the human body (Hinchliffe, 2001; Stassart and Whatmore, 2003).

The third dimension concerns the imposition of standards upon nature, forming a hybrid that can be controlled. This proceeds at first from seeing nature as the essential character and quality of something—for instance, the milkyness of milk. Defining that essence is a difficult task but it is a means by which our individual observations may be compared and if necessary standardized. Once negotiated on the basis of their "innate, essential, eternal, nonnegotiable" characteristics, such definitions are very powerful (Cronon, 1995, page 36). Since the advent of the Enlightenment, not only have such definitions become the basis of scientific measurement and therefore of the practice of science, but they have also been appealed to as a source of moral authority. Whatever is deemed to be natural therefore excludes or marginalizes the 'unnatural' alternatives. Although there were fears in the 19th century about the manipulation and adulteration of various foodstuffs, there is absolutely no doubt that it was milk that was the main problem in the minds of consumers at that time. There is a vast literature, flourishing

from about 1880 to 1930, showing that our present-day views of milk, as a frankly rather dull commodity of somewhat uncertain nutritional value, are out of line with its highly colourful and controversial past.

The body's experience of milk is one of dependence in infancy, but as adults our ability to sense its natural and unnatural variations is limited. Adulterated milk, for instance, cannot be detected by sight or smell unless the amount of added water is so great that it acquires a bluish tinge. The body ethics of the period before about 1930, particularly for nonbreastfed babies, were dominated by the thought that the consumer was vulnerable to the ingestion of 'unnatural' foods, and a premium was therefore increasingly put on trust in the supplier and in the expert systems that were supposed to regulate the food supply. This bodily connexion to the 'other' from the early 20th century was mediated through legislation, regulation, and the law, drawing authority in the common law from the ethics of 'proximity' (for the relevance of Lévinas's discussion of proximity, see Atkins et al, 2006; Manderson, 2006).

Milk in most species is white but closer inspection reveals a remarkable variation in composition. Even among specialist dairy breeds of cattle, the term 'milk' in effect is a homonym for liquids containing more or less butterfat and more or less solids-non-fat. So what is natural milk? Because it is so hard to define, milk proved to be exceptionally difficult to regulate unless standardized. The politics of milk arose out of the clashing interests, with regard to quantity and quality, of farmers, wholesalers, retailers, and consumers; the local and the central states were called upon to provide a framework within which all actors would find safeguards. I will return to this point later but the immediate task is to consider milk's emergent qualities.

Qualities and disqualities

> "The characteristics of a good are not properties which already exist and on which information simply has to be produced so that everyone can be aware of them. Their definition or, in other words, their objectification, implies specific metrological work and heavy investment in measuring equipment. The consequence is that agreement on characteristics is sometimes, in fact often, difficult to achieve."
>
> Callon et al (2002, pages 198 – 199)

With regard to the product of nature, they are often portrayed as the result of artifice, nature seen "coldly as a set of objects, on which men could operate" and where "it was natural to reshape it to a dominant need" (Williams, 1980, pages 77, 79). Unless it is collected wild and eaten raw, all food is artifice right from the stage of planting, to cultivation, to processing, to the use of a recipe in cooking. There is no surprise that foodstuffs are susceptible to social construction but, as yet, few guidelines exist on the means by which this may have taken place in the processes of transduction (the production of structure) and individuation (production of characteristics). Simondon (1964) suggests several. First, materiality is not a set of static characteristics but has an emergent dynamic that is partly based on its properties as a 'preindividual' and partly upon its inherent potential for change. In this sense we should abandon our limiting perception of objects in the here and now and substitute an understanding of being as events. This idea influenced Deleuze's philosophy of difference (Deleuze and Guattari, 1987; Toscano, 2006, chapter 6). Second, material is transduced between successive states in the process of individuation, a process that has intrigued philosophers since Aristotle. Transduction has proved to be of particular interest to geographers in the recent literature on respacings through the medium of code (Dodge and Kitchin, 2005). Third, the material individual cannot be separated from its surroundings, with which it is mutually constituted, and must therefore be defined relationally. Overall, Simondon's

conclusions are rather different from those of social constructivism in as much as transduction is not based on any essential difference between human and nonhuman. Agency is not vested in an actor or an object but "occupies an associated milieu" (Mackenzie, 2005, page 396).

An example is the complex and unresolved value of milk. An initial problem is that we are linguistically constrained: we do not have the multiple terms that the Inuit have for snow, because, until the last fifty years or so, milk was surprisingly undifferentiated, relative at least to our modern retail cornucopia. In the early 19th century, milk was milk, although skimmed milk, butter milk, and whey were obtainable as byproducts of manufacturing. Even now, our mental picture is still of a pure white fluid that bears in its elemental simplicity the burden of many meanings. Until the mid-20th century, views of food quality and variety were reductionist, seeing only the simplest categories. This favoured an ontological minimalism: an assay of material reality that was limited by both technology and imagination.

But the 19th century was also an age of anger, because of the perceived universal cheating over the adulteration of foodstuffs—milk in particular—and the pathological lying to cover it up. This was coupled with frustration at the apparent unwillingness of science to take food seriously and at the absence of technologies able to detect fraud. In the absence of the measurement priority so characteristic of later phases of modernity, there was no palliative for the general sense of ontological instability and unease. In Kantian terms it was first necessary to create the precondition for the possibility of a phenomenon by imagining the composition of a natural, whole milk in order then to understand its deviant forms.

It would be reductive to claim that the process of commodification was alone responsible for the pollution and adulteration of the food supply, but some late Victorians certainly thought that the agrofood sector was complicit through its overrapid industrialization. In one sense, they were right, because the acceleration in demand as a result of rising real wages, and the switch by some women away from breast-feeding, overreached the farmers' ability to supply milk. As a result, large numbers of mixed farmers who happened to keep a cow or two were now persuaded to consign liquid milk to the urban markets, along with former specialists in cheese and butter manufacture.

Also recruited to the cause were various dubious methods of expanding the supply or extending the shelf-life of raw milk. There was extensive watering, up to 25% on average in London in the third quarter of the 19th century (Atkins, 1991), and, in the three decades before the First World War, the addition of chemical preservatives such as boric acid and formaldehyde. In the view of one writer, referring to Birmingham, adulteration at one point was so common that it amounted to "an additional water rate" (Liverseege, 1932, page 211). He found that some vendors considered the small fines that went with the detection of the fraud as "a part of ordinary working expenses" (page 211).

By 1960 it was generally accepted that informal changes in milk composition due to deliberate adulteration had "become extremely rare" (Cook, 1959–60, page 128). Dairy capitalists played an important part in improving this and other quality criteria of the basic milk supply (Atkins, 1984). Since the structure of the trade made it difficult for them to compete on retail price, improving the quality to the consumer was the main basis on which they could increase their turnover. Those dairy companies that were large enough to have negotiating muscle, backed up with laboratory facilities, were in a strong position to impose contractual obligations on their suppliers as to minimum standards of milk composition and cleanliness of production. In the last two decades of the 19th century they came to an informal decision that 3% butterfat and 9%

solids-non-fat were appropriate threshold standards and they seem to have been successful in squeezing out of the system much of the adulteration that had previously been associated with farmers and wholesalers, in addition to putting compositional quality on the agenda. The Simondian 'collective' emerged here from the novel power of capitalist agroindustry to use the constituents and qualities of milk to its advantage in ways that previously were beyond the reach of smaller-scale operatives.

Callon et al (2002) have noted in their 'economy of qualities' that the definition of a product's characteristics is modified as it develops and changes. This idea can be extended to long timescales and to the discussion of a commodity, rather than just the products or goods in Callon's analysis. Milk quality has four dimensions and all four have histories and geographies: composition (usually the content of butterfat and other solids); keeping quality (the time that sweet milk retains its palatability); cleanliness (absence of dirt and other extraneous matter); and safety (freedom from bacteria and elements harmful to humans) (Franklin, 1953). Only the first concerns us in this paper. Despairing of their inability to persuade farmers to send rich milk to market, a number of dairy companies experimented with financial incentives. Payment by butterfat content was discussed by the Mackenzie Committee (1922) and, soon after, Edwin White, the managing director of the Midland Counties Dairy Ltd, started bonuses for farmers who supplied above an acceptable threshold. This scheme was discussed as a model at the World Dairy Congress of 1928 (White, 1928) and the idea spread around the United Kingdom in the years up to the outbreak of the Second World War. It is worth noting that any failure on quality grounds had financial implications. The Milk Marketing Board in England and Wales from 1957 reduced payments to farmers producing poor-quality milk if they were unable or unwilling to make the necessary improvements (Cook, 1959 – 60).

Even the cow's metabolism became entrained in the milk food system. Her efficiency as a machine for producing milk of different qualities in varied quantities depended upon her breed, but performing to her full potential also required an appropriate regime of feeding. Neither the breed nor the feeding regime was explored or understood in 1900 in relation to milk production but in the 20th century there was a gradual switch away from Ayrshires and Shorthorns, with their comparatively rich milk, over to Friesian-Holsteins, with their greater yields of thinner milk. Another important change in the 20th century came from 1926 – 27 onwards when glass-lined road and rail tankers were introduced to bring milk to London. These tanks ensured the mixing of the produce of thousands of cows and reduced the likelihood of consumers experiencing the extremes of composition in the milk of one herd or in that of a single animal.

Moving on from qualities, we will look, in the next section, at what Bauman (1991, page 4) has called the 'task of order'. This is the reification and translation of qualities by measurement.

Laboratory science and the task of order

> "Now every [food] factory of any consequence is equipped with its research laboratory, and there are actually more chemists employed in the various branches of the food industry than in any other single industry in the country."
>
> Ministry of Health (1932, page 136)

Knowing the world through classification and measurement has been important for moderns. But such ontological work is not necessarily continuous. Hesserl's concept of 'sedimentation', for instance, sees objectivities (in our case the definition of a key food commodity) as gradually accumulating authority while their origins may be forgotten

(Laclau, 1990), and Jonathan Rée warns lest, with the ageing of concepts and facts, we "take them to be infinitely old and preternaturally wise" (cited in Hacking, 2002, page 6; see also Daston, 2000a). Distance in time or space in this way may lend perceived qualities of naturalness, set apart from the hybridities of immediate human impact. At times this may link to the common Aristotelian understanding of nature identified by Williams (1980) as that portion of the material world that is not of our own making. It is 'out there', an inherent force which directs the world or human beings or both. Thus, histories of the essentials of human life, such as food and drink, may, in their association with that pristine myth of purity, the 'organic', and the romance of a simpler past untouched by chemicals in either agriculture or the processing industries, lose sight of the complex constructions of quality and trust that facilitate the growth of all commodity chains.

Recovering the social and intellectual determinants of commodity histories is complex and difficult. A good starting point is Poovey's wonderful book, *A History of the Modern Fact*, where she traces the genealogy of the epistemological unit. She argues that historical facticity, starting with the Baconian revolution of the 17th century, concerns the failure of universals to "coalesce out of the common experience of particulars" (Poovey, 1998, page 8). Although inspired by Foucault's geneaology and by Daston's 'historical epistemology', Poovey develops her own vision of a contingent historical understanding of the particulate forms of knowledge that is prior to the arrangement and deployment of facts in discursive contexts; and she rejects the Foucaultian focus on the identification of practices or events that constitute temporal ruptures. She uses double-entry bookkeeping as an example of the creation of modern facts, as the disinterested 'nuggets of knowledge' that lubricated trade and allowed the construction of a rule-governed, systematic mercantile knowledge base.

Similarly, Daston and her colleagues at the Max Planck Institute for the History of Science, Berlin, are dedicated to uncovering the cognitive, material, and cultural matrix of scientific practices and normative ideals through histories of objectivity. Her historical epistemology is therefore the history of what counts as knowledge, "the history of the categories that structure our thought, pattern our arguments and proofs, and certify our standards for explanation" (Daston, 1994, page 282). It also celebrates the 'thingness' of objects (Daston, 2004).

Daston (2000b, page 14) sees nature as a "quick-change artist" and she has set up a border post between environment and society to monitor how concepts of the 'natural' are smuggled back and forward with those of the 'social' (Daston and Vidal, 2004). Her project is explicitly about the objects of science—concepts of objectivity, phenomena, and their birth and death—and that makes it, in the opinion of Hacking (2002), ontological, because many of these objects have no recognizable form before the involvement of science, rather like Michelangelo releasing his sculptures from their primordial marble prisons.

The weakness of consumer politics in the 19th century, coupled with the late development of dairy science and the relative ease technically of adulteration, meant that this commodity was frequently sold in a state that was far from being 'natural'. It was commonly adulterated, generally dirty, and often diseased. In fact, milk was undoubtedly the main 'food scare' of the day, and, because of its ontological instability, it was a risk that sat uncomfortably on the boundary between the natural and the social. Only in the 1920s and 1930s did milk at last begin to slough off its image as an uncertain substance that could not be trusted. Human mediation had created the ambiguity and, for contemporaries, it was science, technology, and the law that together would provide a solution through the use of laboratory tests to reveal human dishonesty and the whims of natural variation.

For Hacking (1990, pages 164 – 165) 19th-century 'normality' was at the same time a condition of the "usual, regular, common, orthodox, average", how things are, and also, under Comteian influence, how they ought to be. 'Is' and 'ought' were intertwined and, for compositional science, normative views gradually developed about 'honest' foods. But, Starr (1987, page 47) has observed that "in nature there are no numbers. Observers have to create them", and, in the case of 'natural' milk composition, there were at first no official data beyond those provided from 1875 onwards by the Inland Revenue laboratory. From the 1890s the larger dairy companies hired their own scientists to check that they were not being cheated by farmers, and these observations along with those of local authority laboratories were gradually built into definitive datasets of empirical knowledge. Neither was truly representative, however: the commercial data were at the top end of the market and the local authority sampling strategies were planned to target likely adulterators. Average retail milks would have been somewhere in between.

This industrial-scale creation of data calls to mind Porter's (1995a) assertion that modern society demands what he called 'trust in numbers'. The public ceded judgmental authority to experts on adulteration. Laboratory scientists played their part, as did statistics, because the quantitative analysis of large datasets provided a means of defence against charges of subjectivity. Quantification and standardized laboratory protocols reduced individual discretion and, especially in controversial areas, established 'technologies of trust'.

In one sense there was nothing new here. The insurance industry, with its actuarial science, had been responsible for an age of burgeoning calculability from the early 19th century (Ewald, 1991; Stigler, 1986). The surprise may be rather that the food sciences developed so late, but this is partly explained by the difficulty of dealing with organic materials in a precise manner. Precision was important for deriving quality standards, especially if they were to be legally enforceable. Porter (1995b, page 192) has observed that "the appeal of precision is likely to be felt wherever trust and deference are threatened" but, as Gooday (2004, page 57) has shown, there are "multiple meanings of accuracy" which, on the one hand, imbue it with moral overtones and, on the other hand, put it to work with a burden of exactitude that was impossible without a theory of error.

Once underway, the collection and analysis of commercial milk analytical data seems to have been taken seriously by the scientific community, although it could have been dismissed as biased, so dependent was it upon the funding of the large dairy companies. This is just as well given the overwhelming dominance of corporate investment in this area and the pivotal role of laboratory staff in the evolution of dairy science. In 1924, for instance, the London laboratories of the United Dairies examined seven times more samples of milk and cream than did all of the local authorities in England and Wales put together (Maggs, 1924). Henry Droop Richmond, who was analyst to the Aylesbury Dairy Company for twenty years, in his laboratories alone processed 330 000 samples. Along with Express Dairies, the Cooperative Wholesale Society, and a number of others, these companies dominated research. Few textbooks were available at the turn of the century and Richmond led the field, in Britain at least, with his *The Laboratory Book of Dairy Analysis* (three editions: 1905 – 25) and his *Dairy Chemistry* (five editions: 1899 – 1953), the latter of which was described as "*the* reference book" for all analysts (Hughes, 1960).

In the mid-19th century there was a debate across Europe among statisticians about the significance of variation in datasets, and its relation to nature, human freedom, and state control (Cohen, 2005; Hacking, 1990; Stigler, 1986). From the 1850s German statisticians searched for systematic covariation rather than mere description

of regularities (Porter, 1986). In Britain the administrative locus of statistical data compilation and analysis was more devolved than elsewhere, particularly France, but state biopolitics nevertheless drew strength and legitimacy from high-quality work on the population census and public health statistics (Desrosières, 1998). By 1900 "exact measurement was advertised as a vital accompaniment of commercial, military, and thus imperial triumph" (Schaffer, 1995, page 135) and the resulting statistics were 'cognitive commitments' to think of phenomena in the way decided by the collector (Starr, 1987, page 53). They were crucial in the emergence of norms: thus, the analysis of milk sample data put commercial dairy companies on the moral high ground with their self-proclaimed attempt to use the modern sciences to solve the social ills of a fraudulent and polluted food supply.

But there are samples and there are samples. At first, there was little agreement about how they should be taken in the field, and still less consensus about appropriate modes of laboratory analysis. The Victorian art historian and social commentator John Ruskin apparently did not approve of the use of microscopes because they challenged the "mystery of everyday life" (Davis, 2002, page 79). But such doubts about the penetration of laboratory science into the spiritual and organic realms were swept aside in an empirical rush to understand natural variations through the techniques of physics, chemistry, and statistics, and then to modulate them. This 'knowability' of milk started in Liverpool in about 1800 when the first lactometer was sold under the name of John Dicas (Filby, 1934). It was a modified hydrometer (Dicas had patented his alcohol hydrometer in 1780) that floated in a milk sample, and the specific gravity (weight compared to that of water) inferred from the volume of displacement was an indication of whether the milk had been tampered with by watering or was whole and therefore natural. Normal cow's milk has an average specific gravity of 1.032. In the words of Bensaude-Vincent and Stengers (1996, page 45), applied to a rather different experimental context, Dicas may be taken to be an "anonymous spokesman for nature" by popularizing a simple instrument that made true nature knowable, along with her variations—those 'other' natures.

In reality, lactometers were far from foolproof (Berry, 1993). For instance, cream decreases the density of milk, and a sample's specific gravity can therefore readily be manipulated by skimming part of the cream to raise the density and then adding water to reduce it back to the original reading. Wanklyn (1874, page 8) claimed that "there hardly ever was an instrument which has so utterly failed as the lactometer. It confounds together milk which is exceptionally rich with milk which has been largely watered." The same was essentially true of more sophisticated gravimetric techniques involving Sprengel tubes and Westphal balances, or the many derivatives of the lactometer, such as the thermo-lactometer or the creamometer. The lactoscope, an optical instrument that judged the opacity of milk—the idea being that watered or skimmed milks could be detected by their physical properties (Girard, 1904)—was no more reliable, because the results varied with the size of the fat globules in the liquid.

From the 1870s chemical techniques increased in importance. Whereas the lactometer gave only a 'quick and dirty' measurement of added water, more direct and accurate assessments of butterfat and solids-non-fat became possible. These can be summarized as 'dry extraction' in the 1870s and 1880s, which was gradually overtaken in the 1880s and 1890s by 'solvent extraction' and 'wet extraction' methods.

The demands of the dairy trade and the state for faster and cheaper analytical methods spawned a small industry in devising and marketing laboratory techniques for the mass production of milk analyses. Improvements in timeliness, however, often sacrificed precision. The early favourite in the 1890s was the American Babcock technique, in which suphuric acid was used to dissolve everything in the milk except

the fat. The mixture was then rapidly rotated in a centrifuge to separate the fat, and a percentage could be read off on the graduated neck of the special bottle provided. The time whirling the samples tied up the expensive equipment and therefore hampered a laboratory's throughput. Leffmann and Bearn added amyl alcohol to separate the fat more efficiently and the Gerber acido-butyrometry method was again similar, but ultimately more successful, because of the convenience of its apparatus.

Wanklyn had realized in the 1870s the limits imposed on the precision of his analysis by the quality of the laboratory glassware then available (Egan, 1976). This remained an issue at the turn of the century when the accuracy of the calibration of the special bottles used in the Babcock and Gerber methods was questioned. In 1900 the newly established National Physical Laboratory (NPL) was called in to guarantee the accuracy of the bottles and subsequently they became preeminent in the standardization of equipment and techniques (Ling, 1945), in the sense of a 'centre of calculation' (Latour, 1987). These bottles soon were an important element in the income stream of the NPL and may therefore by fairly said to have had a central role in its early years. Gerber bottles were vital to the dairy industry, not only to monitor quality and reduce adulteration but also to reassure farmers who sold their milk to butter factories that they were being paid a sufficient amount for the fat content of their milk (NPL, 1903).

From the 1890s company analysts built a substantial body of empirical knowledge about the composition of commercial milks. This was the foundation of a new discipline, dairy science, which flourished and eventually achieved academic status at Reading University in 1896. The credibility of this new science depended upon the taking of representative samples and the measurement of their composition. This is a nontrivial task because, as an organic, bodily fluid, milk is extraordinarily variable, according to breed, feed, animal age and health, season and stage of the lactation:

> "If a dairyman cared to separate the yield of each quarter into 20 successive portions, he would find as many different qualities, and he is entitled to sell them all if he so chooses" (Haygarth-Brown, 1928).

The advent of mass-produced scientific data put power into the hands of company analysts. They were now in a pivotal position in the reduction of risk for the public and for the company balance sheet because, under modernity, risk is a means of eliminating indeterminacy or uncertainty, through calculability and, along with their local authority colleagues, they had a virtual monopoly on the truth that was generated. There should be no surprise at all that the first official standards, when adopted in 1901, were those already implemented for years by the large dairy enterprises (Lloyd, 1896). They in turn had looked to America for inspiration. New Jersey (1882) and New York (1884) were the first states to enforce legal compositional standards: 3.0% fat and 9.0% solids-non-fat (Aikman, 1899).

The voices of the local authority and commercial analysts were strident and their representative body, the Society of Public Analysts, was sneeringly dismissive of the efforts of the official government laboratory in Somerset House. The government laboratory had been designated by the 1875 Act as a chemical court of appeal and therefore sat in judgment on the efforts of local analysts. SPA members resented the government scientists being rarely as well qualified as themselves and they deplored the low standard of butterfat content (2.5%) that was used in judging adulteration, which meant that many frauds went unpunished. Somerset House wished to rule out false negatives and err on the side of generosity whenever there was a possibility that the cow had given rather thin but nevertheless genuine milk. Until the 1901 regulations, analysts employed by the local state and by the larger and more reputable dairy companies used substantially higher standards (3.0% fat or higher) and it was by no

means unusual for cases of falsification referred on appeal to Somerset House to be dismissed, infuriating the prosecuting authorities (French and Phillips, 2000).

Analysts were professionalized by the 1875 Act, but the appointment of local authority analysts was not compulsory until 1899 (Dyer and Mitchell, 1932). Even more important than the creation of their élite status, however, was their credibility for scientific objectivity based upon the relationship with their laboratory instruments and the organization of the taking and processing of samples. Significantly, from our point of view, by about 1930 analysts had failed to establish a number of definitive points about natural milk.

First, they realized that genuine milk was a great deal more variable than had initially been thought. This variability was on scales from the daily, to the seasonal, to the annual and was due to several factors. Second, the early, rather simplistic, focus on fat had distorted the industry's understanding of genuine milk and encouraged farmers to engineer a regression to an annual mean for that ingredient, to the neglect of other factors. Milk Marketing Board data as late as 1957/58 showed that, for herds producing milk at a monthly average of below 8.5% solids-non-fat, the worst month was April, with a substantial minority of farmers unwittingly sending presumptively illegal milk to market for a portion of every year (Cook, 1959 – 60).

Overall, the situation for milk is rather different from that described for the water industry by Hamlin (1990). He argues that ideas about water quality were pinned to the symbolic authority of individual scientists rather than to their laboratory processes. As also happened for milk, large numbers of water analyses were undertaken and this contributed to confidence in the rational process of decision making.

Legal ontologies

> "Legal systems are perhaps the most well-developed ontologies in the social world .... Legislation is an attempt to clarify ontologies (or create them)."
>
> Koepsell (1999, page 219)

A key feature of the ontogenesis of commodities is the contestation of the knowledge that is deployed in their identification, objectification, measurement, and classification. With commodities this is crucial because of the commercial imperative of marketing a consensus vision that can be bought into by potential consumers. As we will see, with milk there was a 'hybrid forum' (Callon et al, 2001) of debate that even though views from all of the various interest groups were heard at first lacked what Rip (2003) has called a 'forceful focus'. This was because, first, some in the industry preferred an indefinite commodity because that gave them the maximum opportunity for fraud. Second, although voices in civil society were raised for change, the slow crystallization of their intent meant that lobbying of government was weak and ineffective until after the First World War. Third, the lack of a suitable means of compositional measurement and of a scientific conceptual context left any who wished to intervene rudderless in a sea of public indifference. Legal ontologies eventually provided the necessary forceful focus from the beginning of the 20th century.

The law played a constitutive role in our ontogenetics. Not only did it enforce the statutes but it also moulded their influence through judicial interpretations that at times stretched the spirit of the parliamentary measures to the limit. In this section I hope to illustrate the crucial role of such normative behaviour, from the magistrates' courts right up to the court of appeal.

As Porter observes (1995a, page 195), "courts have been particularly stubborn in believing that science should mean the straightforward application of general laws to particular circumstances." For Bauman (1991, page 9), the sovereignty of the modern

intellect "is the power to define and to make the definitions stick—everything that eludes unequivocal allocation is an anomaly and a challenge." But science is in reality more complex and less certain than these expectations demand, with the result that "the testimony of real living scientists often holds up rather badly in the adversarial courtroom situation" and "research done according to the standards of scientists is often not impersonal and law-like enough to stand up to political and judicial scrutiny." As a result, the science of food analysis had to adjust to the requirements of the law and of lawyers if convictions were to be obtained and adulteration eliminated. Laboratories had to be run with reference to methods of analysis known to be acceptable to the courts, and at levels of efficiency in the processing of samples and the reporting of results that would stand up in court. Local authority inspectors had to become authoritative and personable 'experts', behind whom there was an administrative and scientific weight that was beyond question.

The gradual accumulation of case law after the Sale of Food and Drugs Acts of 1860, 1872, 1875, 1879, 1899, and 1928, and the issue by successive governments of regulations and explanatory circulars, fostered a changing understanding of the thresholds of legality with regard to food. However, the law was unable "to suppress or eliminate everything that could not or would not be precisely defined" (Bauman, 1991, pages 7–8). On the contrary, it revealed, in its pedantic reverence of the statutory text, uncertainties that no one, from farmer to retailer to scientist, had ever foreseen. It created injustice by convicting innocent parties and pardoning the guilty; and it undermined informal trust that had existed in the trade for decades and encouraged the substitution of complex contractual obligations. Such paradoxical outcomes, and the attending inconsistencies of legal interpretation, would be no surprise to Valverde (2003), whose sociology of legal knowledges has revealed a multitude of judicial standards and practices, preventing the fulfilment of the "law's dream of a common knowledge".

One of Foucault's conceptualizations of 'governmentality' addresses the emergence of new thinking in the 19th century about the exercise of power over the population (Foucault, 1991; see also Dean, 1999). Food was certainly an element of this extension of the state's legitimate sphere of interest and the law on adulteration was an important subset, of both governance and discipline. The calculative rationality of social insurance, well-established by the second half of the 19th century, had helped to embed notions of risk in the popular mind. Politicians began to take note of the parallel scope for a preventative strategy of legislating against both fraud and various forms of pollution and disease in the food supply. Early anti-adulteration laws—for instance, the Sale of Food and Drugs Act of 1860—did not work because the government was divided on how tough to be. Also, creating successful legal regimes required a public that would assent in the regulation of food suppliers and in the manufacture of a docile, responsible trade. A means of persuasion was the idea that legally enforced honesty meant greater freedom for the consumer to choose natural and genuine foods.

The first effective measures against food fraud were the Sale of Food and Drugs Acts 1872 and 1875, after which full-time or consultant analysts were appointed by most of the larger urban authorities (French and Phillips, 2000). Since milk was thought to be the most adulterated of all foodstuffs, it also attracted a majority of the scientific effort. It was during this early period that an infant dairy chemistry took its first steps. At first, the results of sampling were published in the annual reports of medical officers of health and news items began appearing in daily newspapers describing prosecutions. The SPA was founded in 1875 and its professional journal, *The Analyst*, started the following year. It was not until a further Act in 1899, however, that the law was strengthened by making sampling compulsory rather than permissive

for local authorities, and a clause was added that gave government the power to make compositional standards for milk, cream, butter, and cheese.

This power to make regulations governing the ingredients of milk was truly momentous. It ushered in a new era where government was charged with the definition of the natural and the enforcement of that definition in a way that was to shape our view of milk for a hundred years. There was only token opposition to the need for such standards. The Wenlock Committee, reporting in 1901, invited opinions about milk composition but the quality of the evidence varied and it was often self-serving to the interests concerned. The resulting recommendations were not representative of the views of the witnesses outside the large dairy companies and lacked true authority. Barham's minority report objected to one major innovation of the 1899 Act, the introduction of the notion of presumed guilt, which in his view was "contrary to the traditions of English law" (1901, page 425). He was also sceptical of the new idea of an "appeal to the cow", which allowed farmers under suspicion to have their cows tested, to check whether they were giving natural but poor-quality milk. The testing was never quick enough and in any case it would have been exceptionally difficult to trace the milk back to the herd, let alone to the individual cow (Wenlock, 1901).

Despite these objections, in 1901 the imprimatur of the Sale of Milk and Cream Regulations was given to Wenlock's suggested minima of 3.0% butterfat and 8.5% solids-non-fat. The regulations were 'presumptive' in implying that milk below these standard thresholds was adulterated until the contrary could be proved. They did, however, leave the door open to the percentages of butterfat and solids-non-fat in genuine milk falling below these levels and, strictly speaking, were therefore not normative legal standards, although this is how they were treated in practice.

Within a decade there were grave misgivings expressed about the operation of the Sale of Milk Regulations. These focused on milk that was genuine but poor in compositional quality. For decades the dairy industry relied upon the notion of a 'warranty'. This was an oral or, more usually, a written statement that the milk delivered would be whole and untampered with. Section 25 of the 1875 Act anticipated this as a legal assurance of quality, and it remained until the 1930s as a dealer's main defence against an accusation of watering. The problem was that "upon many points in connection with warranties the mind of the courts has fluctuated": the court of appeal gave a number of puzzlingly contradictory judgments in the first half of the 20th century (Bell, 1931, page 158 – 72).

The tension between the state—as represented through the courts—and the farming community was in some ways the result of different interpretations of the rule of law. The state saw its role as the arbiter of positivist law, made by society for its mutual protection and based on morality only inasmuch as the standards were presumptive and defendants therefore had a chance to prove their innocence. Farmers, on the other hand, were proponents of natural law—the notion that justice is immanent in nature. They argued that compositional rules were unfair if they ignored the empirical experience of natural variation and imposed poorly researched and arbitrary standards. This was in effect the nature of rules versus the rules of nature.

A number of notorious Scottish cases either side of the First World War, which did not go so favourably for the agricultural interest as the three mentioned above, prompted complaints from the Scottish Chamber of Agriculture and the National Farmers' Union of Scotland about vexatious prosecutions. As a result, in January 1922 an interdepartmental committee, chaired by Sir Leslie Mackenzie, was appointed in Edinburgh. Evidence was taken from fifty-two witnesses from all sides of the milk industry (but no consumers). Mackenzie recommended a move from a presumptive to a legal standard and made the innovative suggestion of locally

applicable compositional minima, above the national standard, where support could be demonstrated from civil society. The report also noted that the committee was evenly divided on whether the toning of milk down to such a standard should be allowed. On the subject of prosecutions, Mackenzie commented that "it is no wonder if such a clumsy method of dealing with a very complex article of food should occasionally give rise to injustice" (1922, page 899). Wrongful convictions were possible and, according to the contemporary literature, common, but the law was not particularly helpful in tracing the real source of fraud.

Mackenzie's recommendations were ignored by successive governments. It was not until 1951 that the Minister of Agriculture appointed a working party chaired by Sir Reginald Franklin on the same topic, to look into producers' prices with a view to incentivizing improvements in composition and quality. Its report, published in 1953, recognized the difficulty of a national scheme of payment by quality because of the lack of adequate testing facilities to allow weekly or fortnightly testing (Franklin, 1953). This was not insuperable, however, as shown by schemes already operating in Australia, New Zealand, and some European countries.

One of the reasons for the Franklin report was a general feeling that the quality of milk had declined since before the Second World War. The conclusion, drawn from a complex dataset, was that there had indeed been some deterioration in compositional quality over the previous thirty years, with solids-non-fat declining more rapidly than butterfat. The reasons given included the spread of Friesians, as noted above, and also poor stock-feeding regimes during the Second World War and in the agricultural depression of the 1930s. Franklin urged the need for remedial measures that included quality payments and structural changes in the national herd by the encouragement of breeds with a better milk-quality profile. He also noted that milk had already been standardized in Denmark (at 3.5% fat) and the Netherlands (2.5% fat), partly because both countries had important butter industries that profited from the surplus butterfat above these thresholds. Since milk in the United Kingdom was largely sold to the liquid market, it was not such a pressing issue. Later, farmers in the Netherlands opted for payment by protein content as well as by fat.

Soon after, the Cook Committee was appointed, "to consider the composition of milk sold off farms in the United Kingdom from the standpoint both of human nutrition and of animal husbandry and to recommend any legislative or other changes that may be desirable." Reporting in 1960, it found that the average fat content of milk had declined in the first half of the 20th century from 3.7% to 3.6% and that solids-non-fat had declined from 8.8% to 8.6% (Cook, 1959 – 60). It advised against the standardization of milk composition, however, preferring instead the continuing sale of milk "as it came from the cow".

In the late 19th century the desire for honesty had led to the adoption of chemical analysis, and since this could best measure fat so trust in milk came to be vested in that. In consequence, the industry changed to make its profit from the delivery of just enough of the key component to be on the right side of the law. Later, as the 'moral technology' moved on, fat content was no longer such an issue, with protein and lactose also becoming target variables for payment in 1984. Ironically, fat soon came to seem like a bad ingredient as health scares about the link between cholesterol and heart disease circulated in the 1980s. The consumption of liquid milk has been declining steadily since the mid-1960s in Britain as a whole, although other dairy products such as yoghurt have increased sales dramatically in recent years, encouraged by the market-forming power of the large supermarket chains. Since 1981 retail milk has been widely differentiated into whole, semiskimmed, and skimmed, introducing complexities in a market that for two centuries had assumed that only one product was possible.

The most extraordinary recent development, largely unnoticed by the public, has been the legalization by the EU of the 'standardizing' of milk. This practice, so long regarded as an illegal form of adulteration, is now accepted. Since January 1993 whole milk can be mechanically adjusted in composition to a minimum of 3.5% fat, 8.5% solids-non-fat, and 2.9% protein, with a specific gravity of 1.028, and a freezing point of $-0.520\ ^{\circ}C$. The composition issue is now fossilized for the forseeable future and the dairy industry has previously undreamt of freedom to (a) 'manufacture' standardized liquid milk from its components rather than selling it 'as it comes from the cow'; and (b) to use milk powder from all over the world to recreate, as if fresh, one of our most perishable retail products.

Conclusion: after the fact

> "Because the conceptual separation between nature and society as categories is created in practice, and then affects subsequent practices, the result is new relationships between nature and society, even as both are the outcome of historical practice."
>
> Mansfield (2003b, page 330)

In a sense, this paper has been about the philosophical question 'what is an object?', written in the limited terms of the material ontogenetics of a commodity's career. Potentially, this approach has much to contribute to an understanding of the events in the emerging thingness of objects through time and space and their movement towards the familiarity that Miller (1987) calls "the humility of things".

By investigating the emergence of a consensus of what 'milk' is and the policing of material boundaries of that foodstuff, I have attempted a number of insights that have wider significance than the mundane trope of the daily diet. First, the mass marketing of milk is transductive in one sense intended by Simondon (Mackenzie, 2005, page 395). It facilitates the transformation of a variable, perishable, organic fluid, produced by the cow for her calf, into a commercial product loaded with 'technicity'—its standardized constituents, its artificially lengthened shelf life, its purification of microorganisms, and its quality that is reliable over successive iterations of demand and supply. This technicity is itself the result of other transductions—for instance, the invention and evolution of the technology of pasteurization, which in turn depends upon many other interrelations between ideas, speech acts, and materials. No one single act of forming matter is sufficient to comprehend this process of transduction and the resulting individuation. In the case of milk, its organic components continue to interact with each other and with the environment right up to the moment of consumption (and, beyond, in the gut, until metabolized), and 'processing' is therefore largely a means of inhibiting and redirecting the fluid's inherent energies so that its transduction is into a product acceptable to the consumer and not into a degraded or poisonous one.

The boundary work between 'milk' and the various fluids sold as milk, with more or less butterfat and milk-solids content, involved the refinement of a hugely significant new area of science, organic chemistry, and the establishment of an innovative strand of governmentality—food law and regulation. As I have argued elsewhere (Atkins et al, 2006), legal geographies can teach us about the ethical 'proximity' between parties in a chain of service provision, and, in the later 19th and 20th centuries, nature was made less mysterious as a combination of laboratory science and legal standards sought to encompass its compositional variations and bring it into the modern realm of the observed, the regulated, the trusted. In codifying and enforcing the limits of nature, the law was a plane of transcendence, ultimately creating a basis for the discussion of human behaviour and guiding both thought and action in a direction that in reality was at times tangential to the interests of all of the stakeholders. The reduction of risk

was a project in governmentality, "a strategy of regulatory power by which populations and individuals are monitored and managed" (Lupton, 1999, page 87). There was a shift from a collective form of discursive hygienism that arose from Victorian debates about urban dirt and 'the great unwashed', towards control of the production process of individual farmers.

Second, analyzing a commodity not as a point in space–time but as a series of events, benefits from Simondon's notion of transduction, the idea that "a diversity of actors, interests, institutions and practices are articulated together through specific technologies" (Mackenzie, 2002, page 118) into 'collectives', and the present paper has given an account of this in the historical setting of the interactive and mutually constituting flows between various sources of capacity: biological, commercial, legislative, legal, scientific, technical, and consumer politics (DeLanda, 1997). The very complexity and astonishing intensity of activity associated with milk made it a locus of controversy and acrimony, not least because of the indeterminacy of its natural material form and also due to the irresolvable 'vitality' it was assumed to possess, even after the discovery of vitamins (Atkins, 2000). It achieved the status of a technical ensemble at a time when most other foods were simply processed, and it was therefore exemplary from an early date of the regulated and, in Foucault's terminology, 'normalized' foodstuffs that were a major element in the normative thrust of modernity—the production of truth through power. This provided raw material for the transformation and naturalization of society itself. Commercial interests were well served but the large diary enterprises had to sacrifice some of their freedom of action as they became hybrid creatures, gorging themselves on a regular diet of scientific samples and motivated by the need to be more hygienic than their competitors. The rhetoric of trust had been initially fostered by the NMPC and commercial advertising but eventually also medical officers of health and doctors joined in the chorus backing the 'drink more milk' marketing message. Interestingly, the large dairy corporations were selling better quality milk than their small-scale competitors. In the first half of the 20th century their resources for and commitment to quality monitoring were second to none, seemingly the reverse of expectations in the risk society (Dean, 1999; Lupton, 1999), where risks are said to proliferate as a result of corporatism and commodification.

Finally, I conclude that historical geographies of food, and of commodities generally, deserve greater attention than they currently attract. Miller (2005, page 5) understood this when he observed that "objects are important not because they are evident and physically constrain or enable, but often precisely because we do not 'see' them." The everyday material of our lives, including food and drink, because it is unconsidered, because it is unchallenged in its significance, is a powerful means of guiding our expectations—in the case of food, our habituated, embodied norms of nutritional sufficiency and bodily reproduction.

This paper has attempted, by a process of questioning and unsettling the taken-for-granted, to show that the composition of all liquid milk retailed in the United Kingdom bears the traces of scientific, technological, commercial, and legal influences over a period of 200 years. Milk's apparently timeless qualities have hidden, beneath a blanket of innocent whiteness, the significant variations of composition in time and space that are palpable upon close inspection. Only since 1993 have the many milks become standardized into a single, stabilized Euro commodity. Our ontogenetics of this single commodity has sought to reveal its trajectory and the dynamic of its evolution. In doing so, the paper has tried also to redress the "neglect of 'food*stuffs*' " identified by Stassart and Whatmore (2003, page 450, emphasis in original) as a reason for 'the lack of analytical purchase' in the literature on food.

Acknowledgements. I am indebted to Nicholas Cox for sharing his knowledge of the history of statistics, and for making many suggestions for improving the paper. Jonathan Reinarz and Stuart Elden also kindly read early drafts, and I wish to thank three anonymous referees for their constructive comments.

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