Putrid Meat and Fish in the Eurasian Middle and Upper Paleolithic: Are We Missing a Key Part of Neanderthal and Modern Human Diet?

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ABSTRACT

This paper begins by exploring the role of fermented and deliberately rotted (putrefied) meat, fish, and fat in the diet of modern hunters and gatherers throughout the arctic and subarctic. These practices partially 'pre-digest' the high protein and fat content typical of northern forager diets without the need for cooking, and hence without the need for fire or scarce fuel. Because of the peculiar properties of many bacteria, including various lactic acid bacteria (LAB) which rapidly colonize decomposing meat and fish, these foods can be preserved free of pathogens for weeks or even months and remain safe to eat. In addition, aerobic bacteria in the early stages of putrefaction deplete the supply of oxygen in the tissues, creating an anaerobic environment that retards the production of potentially toxic byproducts of lipid autoxidation (rancidity). Moreover, LAB produce B-vitamins, and the anaerobic environment favors the preservation of vitamin C, a critical but scarce micronutrient in heavily meat-based northern diets. If such foods are cooked, vitamin C may be depleted or lost entirely, increasing the threat of scurvy. Psychological studies indicate that the widespread revulsion shown by many Euroamericans to the sight and smell of putrefied meat is not a universal hard-wired response, but a culturally learned reaction that does not emerge in young children until the age of about five or later, too late to protect the infant from pathogens during the highly vulnerable immediate-post-weaning period. Ethnohistoric and ethnographic evidence clearly show that putrefied meat and fish were not used solely as starvation foods, but served instead as ubiquitous, desirable, and nutritionally important components of forager diets throughout these northern environments. In the second part of the paper, I extend these arguments to suggest that putrefied meat, fish, and fat are likely to have been equally important to the lifeways and adaptations of Eurasian Paleolithic hominins inhabiting analogous environments. If such food practices were in fact widespread during the mid- to late Pleistocene, they may help account for aspects of the archaeological record that are presently difficult to comprehend, such as the 'on again, off again' evidence for fire use (and hence cooking) during the Eurasian Middle Paleolithic. Putrefaction also may alter the isotopic composition of the diet. As meat and fish decompose, a variety of volatile compounds are produced, including ammonia. Loss of NH_3, along with lesser amounts of two other nitrogenous gases—cadaverine and putrescine—would very likely leave rotted meat and fish enriched in ^{15}N by comparison to the isotopic composition of these foods in their fresh state. Such enrichment may have contributed to the elevated values seen in many Neanderthals, values that are widely taken as *prima facie* evidence of Neanderthal's status as a 'top predator.' Finally, if Paleolithic foragers relied upon putrefaction to prepare and store meat, archaeologists may have to rethink the way they interpret a number of widely used taphonomic signatures, including the number and distribution of cutmarks, the extent of carnivore damage, the incidence of burning on both animal bones and stone tools, and the frequency and scale of hearths, ash lenses, and other features of combustion.

"When we fix salmon head we put it in bucket in ground and we take it out and eat it. We leave it in ten days only because it will spoil in summer.... Stinkfish, oooh, I love that stinkfish. Smell funny, but it sure taste good...." (Mary Tyone, quoted in Godduhn and Kostick 2016: 30)

INTRODUCTION

By nature most Paleolithic archaeologists—myself included—are empiricists. We want facts and, understandably, we build our interpretations closely around them. After all, what good are interpretations in archaeology if their aim is to account for domains of behavior in the past that we cannot 'see' in the material record? Without the facts, we may be doing little more than weaving fanciful stories out of whole cloth—creating archaeological 'fairy tales' or 'just-so' stories.

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On the other hand, there are a number of behavioral domains that for all practical purposes remain archaeologically invisible, or at least frustratingly intractable, despite the fact that we know they are present, even universal, among modern foragers. Gender provides a classic case in point. Gender distinctions are central to hunting and gathering societies across the globe and play a fundamental role in the daily lives of these peoples (e.g., Brumbach and Jarvenpa 2006; Frink 2009). They must therefore have a prehistory, one that very likely extends well back into the Paleolithic. But we remain all but helpless when it comes to 'seeing' gender in the Paleolithic record, where stone tools are just about the only artifacts with which we have to work. Given the male-centric biases that we standardly bring to lithic studies, coupled with the inadequacies of the methods at our disposal and the almost total lack of suitable middle range theory (Gero 1991), we are compelled to pay little more than lip service to the issue. As a consequence, there is considerable risk that a portion—quite likely a substantial portion—of the variability that we are trying to explain in Paleolithic stone tool assemblages derives from gendered behavior, not from the usual list of 'suspects' to which we almost invariably turn (e.g., differences in raw material, site function, cultural tradition).

Unlike gender distinctions, which most Paleolithic archaeologists are at least well aware of, there are potentially important domains of past behavior that are not only archaeologically invisible, but have almost never received even so much as lip service. One such domain—the focus of the present endeavor—concerns the use of deliberately fermented (often literally rotted or putrefied) meat, fish, fat, and stomach contents. Ubiquitous today and in the recent past in the foodways of foragers throughout the circumpolar regions (Yamin-Pasternak et al. 2014), and important even well beyond the northern latitudes (Audubon 1897: 496–497; Barnes et al. 1973; Buck et al. 2016; Budack 1977; Cawthorn 1997; Coues 1897: 356–357; Darwin 1860: 213–214; Dirar 1992; Dornan 1925: 115; Ealy 1880: 134–135; Grey 1841: 276–278; Griffiths 1975; Johnston 1908: 627; Kelsey 1997: 204; Marlowe 2004a: 191; Newcomb 1961: 41; Oyewole 1997; Selous 1881: 436; Winship 1896: 528), fermented and rotted animal foods are—or at least were until quite recently—key dietary staples that were absolutely vital to the viability and success of these northern foraging groups.

An admittedly cursory scan of the literature using *Google Scholar* revealed a smattering of articles over the years which briefly mention—usually in just a sentence or two—the possibility that Paleolithic foragers might have eaten fermented foods, most notably the stomach contents of certain ungulates and birds. However, as far as I have been able to determine only two of these papers, both very recent ones, actually made this possibility a central focus of their study (Buck and Stringer 2014; Buck et al. 2016). The near universal silence on this topic is curious given that Eurasian Neanderthals and their Upper Paleolithic successors occupied habitats not all that different from the tundras, arctic steppes, and boreal forests that are, or were, home to northern foragers of the 'ethnographic present.' More to the point, these are precisely the kinds of environments in which modern foragers routinely relied on fermented and deliberately rotted meat, fish, fat, fish roe, and stomach contents. In fact, many explorers, ethnographers, ethnohistorians, and nutritionists over the years have concluded that life in northern environments might not have been possible without frequent recourse to fermented animal foods (Kozlov and Zdor 2003: 129). So, is it not likely, or at least plausible, that Neanderthals, and perhaps even their predecessors, as well as Upper Paleolithic foragers, might have done likewise?

WHY DOES IT MATTER TO PALEOLITHIC ARCHAEOLOGISTS?

There is much more at stake in the answer to this question than merely adding some offensive smelling oddities to the culinary repertoire of our Pleistocene forebears. For reasons to be discussed shortly, if fermentation of the type seen historically in the northern latitudes was also practiced as an alternative to cooking *on a more-than-occasional basis* by Eurasian Neanderthals and Upper Paleolithic hominins, we may have to modify, in some cases quite radically, the way we go about reconstructing many aspects of their behavior and lifeways, including, among others: (1) estimating the metabolic costs of digesting and assimilating the large amounts of protein in a heavily meat-based diet (Churchill 2014: 325; Speth and Spielmann 1983); (2) accounting for the on-again, off-again evidence for fire (and hence cooking) in the European Middle Paleolithic, and in particular the seemingly counterintuitive decline in the incidence of fire use (in at least some sites) during colder climatic episodes (Sandgathe et al. 2011; see also Sorensen 2017); (3) broadening our view of the potential range of hominin food preservation and storage capabilities and consequent patterns of site occupancy and mobility; (4) assessing what impact, if any, the repeated consumption of millions upon millions of bacteria and their complex metabolites, together with the normal postmortem biochemical products of endogenous muscle and lipid decomposition, might have had on the carbon and nitrogen stable isotope values of Neanderthals and Upper Paleolithic peoples (Bocherens 2011; Richards and Trinkaus 2009); and, (5) developing taphonomic signatures that take into account the impact that non-thermal fermentation and putrefaction are likely to have had on signs of anthropogenic involvement in assemblage formation (e.g., the frequency of charred bones, the abundance and anatomical distribution of cutmarks), the survivorship of fish bones and other fragile faunal remains, and the extent to which discarded bones from deliberately fermented or rotted carcasses would have remained attractive to predators and scavengers. Fermentation may be like gender—frustratingly intractable yet fundamentally important to our understanding of the behavior and adaptations of our Pleistocene ancestors.

FERMENTATION AS A 'LOW-TECH' ALTERNATIVE TO COOKING

There are a number of reasons why fermented and rotted foods would be important to peoples, whether Paleolithic or more recent, living under arctic and subarctic conditions. First and foremost, fermentation (including more advanced states of putrefaction) of meat and fish accomplishes outside of the body much of what would normally happen to these foods in their unfermented state inside the body after one has ingested them (Kozlov and Zdor 2003). In other words, in many respects fermentation, through the combined postmortem proteolytic effects of endogenous enzymes in the carcass and the products of both endogenous and exogenous microbial action, becomes a powerful and low-cost way of *pre-digesting* both meat and fish, softening them significantly and breaking down the proteins into peptides and amino acids (Fadda et al. 2002; Forbes et al. 2017; Ordóñez and de la Hoz 2007; Petäjä-Kanninen and Puolanne 2007). The same endogenous and exogenous processes also contribute to the breakdown or lipolysis of fats in the food, liberating a range of nutritionally valuable free fatty acids (e.g., Forbes et al. 2017; Vasundhara et al. 1983). In essence, fermentation (and more advanced stages of putrefaction) produce many of the same benefits that cooking does, *but without the need for fire or fuel* (Wrangham 2009; Wrangham and Conklin-Brittain 2003; see Urquhart 1935: 195 for an early recognition of these metabolic benefits). And, though admittedly speculative, I suspect that the more advanced the stage of fermentation or putrefaction, the greater the energetic benefits to the consumer.

Moreover, lactic acid bacteria (LAB), which play a key role in the fermentation process, produce a wide range of enzymes, toxins, and other metabolites that inhibit invasion by unwanted pathogens such as *Clostridium botulinum*, the agent that causes botulism, and many others (Alakomi et al. 2000; Axelsson 2004; Caplice and Fitzgerald 1999; de Moreno de LeBlanc et al. 2015; Fadda et al. 2002; Farouk et al. 2014; Holzapfel and Wood 2014; Liu et al. 2014; Ray and Joshi 2015; Riley and Chavan 2007; Ross et al. 2002; Singh et al. 2012; Stadnik and Kęska 2015). The ability of LAB to block the proliferation of pathogens provides arctic and subarctic foragers with an extremely effective 'low-tech' way of preserving and storing meat and fat for months—even through the warmer months of the year—in environments where the weather often was too damp and rainy to dry these foods effectively, and especially in environmental contexts where fuel shortages may have precluded the routine use of fire to speed up the drying process. The food was often simply placed for weeks or months in pits in the ground (Jones 2006), or under piles of rocks, or within specially made seal-skin 'pokes' (Frink and Giordano 2015), or submerged in bogs, rivers, or shallow ponds (Fisher 1995), and later retrieved and consumed with no ill health effects.

And while these techniques are best documented in the northern latitudes, they have been noted in other areas of the world as well. For example, 17th-century Dutch colonists observed Khoisan hunter-gatherers ('strandlooper' Bushmen) along the Namibian and South African coast scavenging meat and blubber from stranded whales and storing it in pits along the shore for later use (Budack 1977; Raven Hart 1971; see also Cawthorn 1997 for similar practices among Maori of New Zealand and Darwin 1860: 213–214 for comparable treatment of beached whales in the high-latitude environments of Tierra del Fuego). A Native American war party taking a group of captives from farms in western Pennsylvania to the Niagara frontier area in western New York in 1780 apparently did not hesitate to eat a putrid and maggot-infested deer (or elk) they killed en route (Walton 1790: 103–104). And as Frank Marlowe (2004b: 84) notes, even the well-known Hadza in Tanzania were not averse to utilizing putrid meat: '...the Hadza often eat very rotten, week-old meat they scavenge from carnivores.'

The preservative effects of LAB fermentation also are invaluable in preventing fats from becoming rancid. For arctic and subarctic peoples subsisting on diets that were composed almost entirely of animal foods, the large quantities of fatty meat and fish that such a diet demands can be very difficult to dry quickly enough and thoroughly enough to prevent the lipids, most especially the long-chain polyunsaturated fatty acids (LCPUFA's), from turning rancid and spoiling (see the discussion in Romanoff 1992). Such spoilage can actually pose a health risk by giving rise to a number of undesirable and potentially toxic substances in the meat or fish. The most important of these are a class of compounds known as hydroperoxides, unstable oxidation products that can undergo further breakdown, forming a variety of carbonyl group compounds such as aldehydes and ketones (Kubow 1990; St. Angelo 1992). These same processes can also lead to destruction of important vitamins in the fish or meat, particularly vitamin C, but also vitamins A and E (Flick et al. 1992: 184).

Fermentation provides an effective means of inhibiting the 'autoxidation' of the lipids that leads to rancidity. When decomposition first begins, the microflora in the carcass at the time of death is predominantly composed of aerobic taxa. These bacteria deplete the available oxygen, rapidly transforming the aerobic environment in the carcass (and meat) toward one favoring fermentative anaerobic taxa (Finley et al. 2015: 628; Forbes and Carter 2016: 19; Hyde et al. 2013: 7). For the very same reason, fermentation may be one of the most effective ways to preserve and store the lipid-rich brains of both fish and mammals, because the two principal LCPUFA's in brain, docosahexaenoic acid (DHA) and arachidonic acid (AA), are very unstable and quickly turn rancid, even when refrigerated.

Finally, LAB fermentation creates important B-complex vitamins, most notably vitamin B_{12}, riboflavin, and folate; and, by reducing or obviating the need for cooking, whether by roasting or by boiling, and by retarding the autoxidation of lipids, fermentation favors preservation of these and other vitamins that might otherwise be diminished or lost (de Moreno de LeBlanc et al. 2015).

VITAMIN C

Let me digress briefly here to take a closer look specifically at vitamin C. Early Euroamerican explorers in the arctic were plagued by scurvy stemming from shortages of vitamin C, while their unacculturated Native hosts were not (Fediuk et al. 2002; Stefansson 1935). The problem often arose, not from what the Westerners were eating—they were often relying on the same animals as their hosts were—but from differences in what parts of the animals they ate and how they prepared the food. The outsiders typically preferred muscle meat over entrails and organs, and they generally wanted it cooked (preferably roasted or grilled), not raw or frozen, and cooked thoroughly, especially if the meat was 'tainted' (as it often was on long outings in the 'bush'). Coastal Inuit and inland Natives, on the other hand, ate virtually every part of the animal, including all of the internal organs, blood, testicles, foetus, amniotic fluid, intestines, chyme, brain, and eyes; and, they typically ate these either raw (sometimes still warm straight from the animal, sometimes partly frozen), or fermented (in fact, often thoroughly putrefied).

As it turns out, muscle is virtually devoid of vitamin C, regardless of how it is prepared, whereas many of the organs and body fluids that most Western visitors found disgusting and assiduously avoided (except when their expeditions were teetering on the brink of starvation) are precisely the portions of the animal that have the highest vitamin C levels (especially the brain, liver, spleen, and testicles, but also the thymus, pancreas, eyes (retina), adrenal glands, pituitary gland, and to a lesser extent the kidneys, heart, and lungs; see Clemens and Tóth 2016; Fediuk et al. 2002: 227, Table 1; Harrison and May 2009; Hediger 2002: 445; Jayathilakan et al. 2012: 281; Kizlaitis et al. 1962; NUTTAB 2010 Electronic Database; O'Dea 1991: 236; Pearson and Gillett 1999: 42). Curiously and perhaps counterintuitively, the stomach contents, at least of caribou, turn out to be a rather poor source of this important micronutrient (Draper 1978: 310; Fediuk 2000: 54). In any case, regardless of whether one ate the full array of body parts and fluids separately while still raw, or consumed them mixed together into a thoroughly putrefied mass, there was enough of this precious vitamin to remain healthy.

Moreover, as already demonstrated early in the 20th-century, one can live indefinitely on a diet containing no fruits or vegetables and no fish or other aquatic foods and still obtain sufficient vitamin C to stave off any symptoms of vitamin C deficiency or scurvy, so long as the animal foods that are eaten are either raw (i.e., fresh, frozen, or putrefied) or only very lightly cooked (Bender 1979; Kizlaitis et al. 1964). Karen Harry and Liam Frink (2009: 334) provide a clear idea of what 'lightly cooked' typically meant in high-arctic contexts where fuel was scarce: 'Modern-day informants report that traditional cooking techniques, still preferred by many today, involve only briefly immersing chunks of meat into hot water and removing them as soon as they have been warmed through or only lightly parboiled....'

In a classic year-long study, two seasoned arctic explorers, Vilhjalmur Stefansson and Karsten Andersen, lived for an entire year in New York City under close medical observation on a diet that consisted solely of (lightly cooked) beef, lamb, veal, pork, and chicken. The parts they ate included muscle, liver, kidney, brain, bone marrow, bacon, and fat. McClellan and DuBois (1930: 661–662), who supervised the medical component of the experiment, found no evidence of vitamin C deficiency. Stefansson (1935: 183), based both on the outcome of that study and on his years of first-hand experience in the arctic, concluded that '...the human body needs only such a tiny bit of Vitamin C that if you have some fresh meat in your diet every day, and don't overcook it, there will be enough C from that source alone to prevent scurvy.'

Similar observations were made some years earlier by William Thomas, a medical doctor who examined traditional Greenland Inuit still living on a diet consisting almost entirely of raw meat. Of particular interest are his comparisons between the Greenlanders and more acculturated Inuit living in Labrador: 'This diet furnishes him [the Greenland Eskimo] with vitamins adequate for protection against scurvy and rickets, while the Labrador Eskimo, whose meat is cooked and whose diet includes many prepared, dried and canned articles, is very subject to both these maladies' (Thomas 1927: 1560; see also Urquhart 1935: 195).

In fact, awareness of the antiscorbutic benefits of traditional northern diets is evident long before the discovery of vitamin C. One of the most explicit and insightful of these was by an 18th-century American M.D., John Aiken. Being unaware of micronutrients, he concluded that scurvy was not the inevitable outcome of an all-meat diet, as many of his contemporaries staunchly maintained, not even if the meat was putrid, but of the heavy use of salt as a preservative:

> "In a manuscript French account of the islands lying between Kamtschatka and America...I find it mentioned, that 'the Russians, in their hunting voyages to these islands, (an expedition generally lasting three years) in order to save expense and room in purchasing and stowing vegetable provision, compose half their crews of natives of Kamtschatka, because these people are able to preserve themselves from the scurvy with animal food only, by abstaining from the use of salt.'" (Aiken 1789: 346)

> "...it seems to be a fact, that several of the northern nations, whose diet is extremely putrid, (as before hinted with respect to the people of Kamtschatka) are able to preserve themselves from the scurvy; therefore, putrid aliments alone will not necessarily induce it." (Aiken 1789: 347)

While it was known already by the mid-18th-century that fresh citrus fruits could both prevent and cure scurvy (Lind 1753), seafaring crews soon discovered that the concentrate made from the juice and used on long sea voyages lost much of its effectiveness as it was being prepared (Kodicek and Young 1969: 46). Thus, more stable alternatives to citrus were clearly needed. Not long after Lind's discoveries, an interesting alternative was put forth by

Charles de Mertans (1778). He found that fermented cabbage (i.e., sauerkraut) possessed an essence or substance that effectively staved off scurvy and, because it was fermented, it could be safely stored for months aboard ships without losing its antiscorbutic potency, thereby finally providing sailors with welcome relief from one of the true scourges of life at sea. De Mertans's insights played a role in Captain James Cook's decision to rely heavily on sauerkraut ('sour-krout') as an antiscorbutic during his long voyages of exploration in the Pacific, because, in Cook's own words, it had '...the good quality not to loose any part of its Efficacy by Keeping, we used the last of it in September last after having been above two years on board & it was then as good as at the first' (quoted in Kodicek and Young [1969: 48]; see also Holzapfel et al. [2003: 348, 350, 353] for contemporary information on sauerkraut's vitamin C content; and Lamb [2016] for an interesting overview of the discovery of scurvy's cause and ultimate cure). Stretching things a bit, one might say that northern foragers, when they first began deliberately fermenting meat and fish, had come upon an animal equivalent to Captain Cook's 'sour-krout'—an easily prepared, long-lasting antiscorbutic that made life possible in a cold and barren world that was largely devoid of fresh fruits and vegetables.

Indulging now in a bit of speculation, if Neanderthal tastes were broadly similar to what we observe cross-culturally among northern foragers of the ethnographic present, such that they had no qualms about consuming the organs, entrails, and body fluids of the animals they procured, and if fermentation (and putrefaction) were normal parts of their culinary repertoire, then, despite their apparent very limited use of marine mammals and fish, it seems rather doubtful that they would have suffered to any significant degree from vitamin C deficiency or scurvy (*contra* Guil-Guerrero 2017).

FERMENTED VERSUS RAW MEAT AND FISH

I should mention one other point before we turn to a closer look at fermentation and putrefaction. Northern peoples eat quite a bit of their meat and fish raw, sometimes frozen (though usually deliberately partially thawed to achieve a crystalline but not flaccid texture), sometimes dried (occasionally also smoked), sometimes still warm from a freshly killed carcass. In short, raw and fermented/putrefied foods are not components of mutually exclusive dietary systems. Quite the contrary, both are widely used across the width and breadth of the circumpolar regions. And they share a number of valuable features in common. Being uncooked, neither requires much if any use of scarce fuel. And being uncooked, both preserve their precious vitamin C content. And, of course, raw meat and fish can be either dried or frozen and stored much like their fermented counterparts, although it would seem from ethnohistoric and ethnographic descriptions that the steps needed to prepare the raw food for storage, especially by drying, required a greater investment of time and labor, and the outcome was subject to greater risk of spoilage from inclement weather.

Where raw and fermented foods are most likely to part company, however, is at the point of consumption, digestion, and assimilation—the costs to the forager in time and calories of ingesting (chewing) and metabolizing them (i.e., the *diet-induced thermogenesis* of the foods). Fermentation, especially when allowed to reach the more advanced states of decomposition or putrefaction, is in many ways akin to cooking the food. Like cooking, fermentation greatly softens the meat and breaks down the component proteins and fats *before* the food is ingested. Thus, for the high-protein diets so characteristic of northern environments, fermentation and more advanced putrefaction may offer foragers a significant energetic benefit, while at the same time requiring little or no use of fire and fuel.

Inuit sled dogs provide additional insights into the potential energetic payoffs of consuming food in a partly pre-digested or putrefied state. During the winter, the season when sled dogs endure their heaviest work loads, their average daily caloric needs are estimated to be on the order of 5,000–6,000 kcal (Gerth et al. 2010; Olesen 2014: 233; Orr 1966), a staggering amount when one considers that these energy needs, and the food that has to be procured to fulfill them, are as great as, and at times even greater than, the needs of their human owners (see, for example, Spencer 1959: 142). As succinctly put by Frank Vallee (1962: 39): 'The average [Inuit] family which had kept one or two dogs before the trapping era would likely have kept from three to six during that era. From the point of view of food consumption, this would be roughly equivalent to adding a few human members to each family in the region.' To help further contextualize these figures, *non-working* Alaskan Huskies (average weight 33.4kg or about 74lb), while exposed to arctic winter temperatures with minimal shelter, consumed on average about 2,600 kcal per day (Durrer and Hannon 1962). At the other extreme, Alaskan sled dogs bred for racing, such as those which participate in the famous *Iditarod*, consume some 10,000 to 11,000 kcal per day (Hinchcliff et al. 1997; Kronfeld 1973; Loftus et al. 2014). Thus, under traditional conditions, and most particularly in winter, sled dogs were a double-edged sword for their owners, on the one hand playing an essential role in the foragers' mobile hunting way of life, but on the other hand requiring a huge and near constant investment of time, effort, and resources just to keep them fed (Anderson et al. 1998: 18; Balikci 1989: 115; 2002: 258; Ekblaw 1928: 3; Hall 1978: 210–211; Krupnik 1993: 54; Leechman 1954: 17; Pike 1892: 55, 136; Prichard and Gathorne-Hardy 1911: 32; Rasmussen 1930: 15, 36; Savishinsky 1975: 474; Smith 1991: 128; Spencer 1959: 142; Tyrrell 1897: 25; Vallee 1962: 38–39; Whitney 1910: 90). As Don Dumond (1980: 41–42) put it: 'Burdened with their growing array of specialized and necessary tools, the Eskimos were driven to invent first the umiak and then the dogsled, having to make payment for the latter ever after in extensive hunting and fishing directed only at finding dogfood.'

James Urquhart (1935: 195), already in the 1930s, observed what he interpreted as the metabolic boost that hard-working sled dogs might gain by consuming fish that were in a fermented or 'high' state rather than fresh.

Though far from a controlled experiment, he noticed that dogs feeding on a diet of fresh fish lost weight, while those eating fermented fish held their weight or actually gained a little. Other arctic visitors noted what may be an expression of the same phenomenon—sled dogs sometimes refused to eat meat, fish, or fat when it was fresh, clearly preferring the fermented or rotted varieties (e.g., Rae 1850: 126; see also Leechman's 1950: 132–133 amusing description of the food preferences of Inuit dogs). Urquhart came to the conclusion that the behavior he observed in sled dogs stemmed from the fact that the 'high' fish were already partly predigested by the fermentation process, and hence could be ingested and assimilated by the dogs with less effort and at less caloric cost than was the case when the fish were fresh (see Stefansson's 1920 alternative and, in my view, rather far-fetched way of explaining what appears to be the same behavior in his sled dogs). It is worth noting in this regard that dogs worldwide have no problem consuming carrion (e.g., Gipson and Sealander 1976; Kamler et al. 2003). In fact, free-ranging domestic dogs in rural areas of Zimbabwe have been so successful at locating and scavenging carrion that they are actually outcompeting vultures and, at least in some instances, even hyenas. Vultures seem to be facing similar intense competition from free-ranging and feral domestic dogs in other parts of Africa as well (Butler and du Toit 2002; see also Vanak et al. 2014).

Thus, it seems clear that eating fermented or putrefied meat and fish offered important benefits to northern foragers. But so too did eating these same foods raw, whether fresh or frozen. And of course at times northern foragers chose to cook some of their food, although the cooking was almost invariably minimal to an extreme. What we are missing is an understanding of the factors that ultimately determined the relative importance—both seasonally and annually—of fermented versus raw versus cooked meat and fish in these foodways. This is an interesting issue that would be well worth exploring further in the ethnohistoric and ethnographic realm, as it might provide us with a comparative framework that would be helpful for modeling the role played by these alternative means of food preparation in analogous environments in the Paleolithic.

INSIGHTS FROM FOOD SCIENCES AND FORENSICS

Let me begin by clarifying some confusion that may already have arisen concerning the meaning of terms like 'fermented,' 'spoiled,' 'rotted,' 'putrid,' and 'rancid.' In popular usage, if someone describes meat as 'fermented,' I think most of us would assume that it is safe to eat, though not necessarily something we would find personally to our liking. However, if a meat or fish product is described as 'spoiled,' I think we would assume it is something we should *not* eat, and it may in fact be unsafe. And I doubt there would be any hesitation about what to do with meat or fish that is characterized as 'rotten' or 'putrid.' Foods in that state of decomposition would be destined for the trash can or compost pile at the earliest opportunity.

But this is precisely where things become confusing, the point where cultural values and practices become inextricably mixed together with genuine issues of health and safety. And this confusion is not just in the way these terms are used in day-to-day parlance but spills over into the scientific literature as well. Thus, when a murder victim dies and the body starts to decompose, a forensic scientist would be likely to refer to what was happening as the onset of 'putrefaction.' In contrast, a food scientist dealing with pork sausages *at exactly the same stage of decomposition* would refer to the process as 'fermentation' (compare, for example, Lana and Zolla 2016, and Pittner et al. 2016: 422). And, counterintuitive as it may seem, even meat that is so putrid that it literally reeks and is filled with maggots may nonetheless be perfectly safe to eat, the smell notwithstanding. In other words, just because meat is putrid does *not* mean it contains unsafe levels of pathogens—'putrid' and 'pathogenic' are *not* synonymous. And as will become eminently clear in what follows, many, perhaps most, northern foragers, at least until quite recently, actually considered foods in just that sort of thoroughly putrefied state—maggots and all—as rewarding and delicious. And they appear to have been utterly unfazed by odors that would almost certainly trigger an instant gag reflex among most Westerners.

One additional point needs clarification before we proceed. I use the term 'rancid' to refer specifically to the degradation of lipids in meat or fish in the presence of oxygen, an 'autoxidation' process quite distinct from what happens to lipids that are fermented or putrefied. The ethnohistoric and ethnographic literature frequently conflates these two processes and as a result can be quite confusing, if not downright misleading. Thus, northern foragers were perfectly content to eat meat, fat, and oils that were fermented or putrefied because they knew they were safe and nutritionally beneficial, but they would go to considerable lengths to prevent the fats in meat and especially fish and marine mammals from going rancid, because these could be unsafe to eat or even toxic. In other words, it is important to keep in mind the important distinction between meat and fish that have been fermented, even rotted and full of maggots, from meat and fish in which the fats have become oxidized and rancid.

Let us turn now to the technical literature on *fermented* meat. I was not particularly surprised to find that the vast majority of this literature is commercially oriented, with very little attention to homemade products, but I was shocked by its overwhelming focus on sausages. Moreover, the vast majority of these studies assume from the get-go that meat fermentation requires salt, usually lots of it, and often substantial quantities of nitrites (to maintain an appealing reddish coloration). In addition, the focus of these works is almost invariably on products of the northern hemisphere, especially European ones, and to a lesser extent those of the United States and Canada. Studies of the fermented meats of East and Southeast Asia, at least those published in languages that I can either read directly or translate online (and be rewarded with results that are not complete gibberish), are rare by comparison. Two entire continents—Africa and South America—for all practical purposes do not exist in much of this literature.

And as far as fermentation's past is concerned, the vast majority of authors simply assert what appears to be little more than inherited wisdom, namely that fermentation saw its beginnings a few millennia ago in the Near East and Egypt with the development of beer, wine, and bread. The possibility that fermented foods—both meat- and plant-based—might have been independently developed, and at an equally early date, in the New World is seldom considered, and the idea that fermentation might have its roots, not among farming peoples of the Neolithic or Bronze Age, but among earlier hunter-gatherers, borders on heresy. Needless-to-say, the authors of the vast majority of these studies appear to be utterly unaware that there are peoples like Inuit and Siberian reindeer herder-hunters who still make extensive use of fermented and putrefied meat and fish, and who have probably done so for centuries, if not millennia; and that there is archaeological evidence that not only takes early fermentation out of the Near East, but pushes its origins back at least 9,200 years to the early Mesolithic (e.g., Boethius 2016).

The way 'spoilage' is defined in much of the commercial fermentation literature is also relevant because it is frequently based more on Western cultural values than on actual threats to health. For example, fermented meat products such as sausages typically are evaluated by panels of experts who deem a product 'spoiled' if its taste, odor, texture, or color are 'off' by comparison to some mutually agreed upon standard. It is not surprising, then, that Euroamerican explorers, missionaries, traders, trappers, colonial officials, military personnel, and ethnographers—raised in essentially the same Western cultural milieu as these expert panel members—would bring to the arctic similar cultural values and biases. No wonder they were 'less than enthusiastic' about meat and fish that had been deliberately rotted in the ground or in a river or pond for weeks or months, often to the point that they reeked and were crawling with maggots (*Diptera* fly larvae, probably *Hypoderma* [*Oedemagena*] *tarandi*, Pape 2001; Schrader et al. 2016; Wood 1987; see Guthrie 2005: 6 for an interesting comment about their value as a fat source in the modern arctic and their likely similar role in the Upper Paleolithic). No wonder these visitors were disgusted when their hosts proceeded to eat the maggots right along with the rotten meat, and did so with obvious gusto! To unaccustomed Westerners in their midst, the stench of foods like 'stinkhead' (deliberately rotted fish heads) was so overpowering that even the hardiest visitors had to exit the dwelling to vomit, only to be met with laughter when they re-entered their host's abode (Stefansson 1914: 160).

Aided nowadays by TV, movies, expanding market economies, and intrusive government policies, Western attitudes about food have been rapidly winning out, supplanting the traditional foods and foodways of the north. Younger generations are now embarrassed by 'stinkhead' and 'rotted flipper,' foods once relished by their elders; and, in deference to the newly acquired 'Westernized' tastes of their grandchildren, the elders are abandoning many of their traditional foodways. An unfortunate consequence of the speed with which this transition has taken place is that we are left with little in the way of 'hard' data concerning the traditional ways of fermenting and rotting meat and fish (for examples of wonderful exceptions to this generalization, see Frink and Giordano 2015; Jones 2006): How widespread was the practice of fermentation in the past? How similar or different were such practices among coastal Inuit and interior boreal forest groups? How much of traditional Native diet was comprised of fermented foods? Were foods fermented primarily during certain seasons of the year, or was fermentation employed more or less consistently over the entire year? How were these foods actually fermented or rotted? For example, how big and deep were the pits? How often were seal pokes used rather than pits? When pits were used, what species of plants were selected to line them and what specific properties made them suitable for the purpose? How were the foods placed in the pits? Randomly? Layered? What was the setting of the pits in terms of local topography, hydrology, soils, shade? How much air was allowed to circulate within these pits? How often were foods stored in bogs, ponds, and rivers? In what depth of water? How were the foods anchored so they did not begin to float as fermentation gases began to form? Did they need protection from terrestrial carnivores? From carnivorous fish?

It is clear that the fermentation process is not a simple matter, but one that required a great deal of expertise and practical experience in order to end up with a product that was safe to eat (Frink 2009). This is clearly shown by the significant rise since the 1970s and 1980s in the incidence of botulism—a potentially deadly illness caused by the toxin of the bacterium *Clostridium botulinum*. The marked upswing in botulism occurred hand-in-hand with the introduction of plastic bags, glass bottles, and other supposedly more 'hygienic' methods of fermenting meat and fish (Chiou et al. 2002; Fagan et al. 2011; Shaffer et al. 1990). Cases of botulism remain very rare when these same foods are fermented in below-ground pits or in lakes and ponds using traditional methods (Fagan et al. 2011: 585).

The rapid disappearance of fermented and rotted meat and fish from contemporary Native cuisine, coupled with the prevailing Western view that such foods are 'disgusting' and presumably unhealthy, if not downright toxic, has created the (misleading) impression that 'stinkhead,' rotted meat, and fermented reindeer and ptarmigan stomach contents were at best marginal resources, and more likely served as very minor fall-back or starvation foods that were resorted to when 'preferred' foods were in short supply. I suspect this view has spilled over into the archaeological conscience as well, and is part of the reason why Paleolithic archaeologists have paid so little attention to the issue, despite the fact that the environments that were home to Neanderthals and Upper Paleolithic peoples in Pleistocene Eurasia were broadly similar to those inhabited by northern hunter-gatherers of the 'ethnographic present.' Even some of the key resources were similar (e.g., reindeer, red deer or North American elk, bison, salmon). The difficulty in 'seeing' fermented and rotted foods in the archaeological record certainly has not helped matters, but if no one 'asks the question,' we will never find out just how important these foods might have been to the lives and lifeways of Paleolithic foragers.

Before turning to the ethnohistoric and ethnographic evidence of fermentation and putrefaction among northern latitude peoples, one final point is worth noting here. Food scientists are not the only ones who study fermentation. As already hinted at, that is also what a lot of forensic specialists do. They just use different vocabularies and have quite different ultimate goals (Campobasso et al. 2001; Crippen et al. 2016; Forbes and Carter 2016; Wallace 2016). What the former call 'fermentation,' the latter call 'putrefaction' or 'decomposition,' and, of course, the former are concerned largely about culturally determined standards of taste, texture, color, and smell, while for obvious reasons the latter are concerned, not about palatability or food safety, but about estimating how long a body has been dead—the so-called 'postmortem interval' or PMI. But regardless of whether a homicide victim was buried in a shallow grave or dumped in a lake, the decomposition of the body follows more or less the same trajectory that one sees in the rotted meat and stinkhead relied upon by circumpolar hunters and gatherers—i.e., breakdown of proteins, carbohydrates, and lipids through a combination of endogenous and exogenous processes, shifts in pH and available oxygen, growth of lactic acid bacteria, infestation of corpses by *Diptera* larvae (maggots), and so forth. So, while it may at first seem counterintuitive, archaeologists who seek to develop the middle range theory and methods needed to investigate past reliance on fermented and putrefied meat might benefit greatly by enlisting the help, not just of nutritionists and food scientists, but also of forensic specialists who study the decomposition of corpses. In a surprising number of ways, both are studying the same thing.

ETHNOHISTORIC AND ETHNOGRAPHIC EVIDENCE

Let us now take a tour of the ethnohistoric and ethnographic literature to gain some idea of how meat, fish, and fat were fermented or deliberately rotted. Many of these descriptions focus on marine mammals and fish, but there are also quite a few mentions of caribou and reindeer, some hunted by coastal groups, others taken by inland peoples. In terms of the Paleolithic, marine mammals and fish were clearly far more important to Upper Paleolithic peoples than to Neanderthals, but both hominins made heavy use of reindeer (and of course other ungulates as well). But perhaps the major message of this section is not which specific animals were utilized, but the process of fermentation or putrefaction itself, the many ways it was accomplished, the times of year when such foods were prepared and when they were consumed, and the state of the final products that were considered desirable as food. Though perhaps a bit lengthy, I think this section is best presented using direct quotes, since the original words of the authors convey much better than I possibly could what was involved in the fermentation process and, of particular importance to the present discussion, the relish and gusto with which these Native populations perceived what to most Western observers were viewed as utterly disgusting, noxious, and quite likely toxic foods. These quotes should make it eminently clear that rotted foods were not merely emergency resources when all else failed; these were routinely used and highly desired foods, readily prepared and easily stored over weeks or months, and pre-digested with little and often no need for cooking.

I should point out a few important biases in this potpourri of examples. Probably the most significant one is a direct outcome of my deficiencies as a linguist. By not being able to read any of the Scandinavian languages, and not faring any better with Russian, my sample from northern Eurasia is minimal at best. Someone able to read these languages, particularly as they were written prior to the 19th-century, would undoubtedly find a wealth of additional material. There are of course lots of language translators, both free versions online and expensive commercial varieties, but my experience with both types has been frustrating, to say the least. For one thing, they remain virtually hopeless when it comes to inferring context and, as a result, often generate output that amounts to little more than gibberish, both grammatically and in terms of content. Moreover, such translators are of little or no help in browsing digital libraries full of lengthy 18th-century travel accounts, only in translating brief snippets of text that you already knew about in advance. In any case, the result is that my sample is heavily biased toward the North American arctic, and to sources either written in English or subsequently translated into English by someone fluent in the language.

Another key source of bias arises from the fact that Euroamerican explorers visited the more sedentary coastal peoples, both Inuit and Northwest Coast groups, far more often than they did the mobile hunting bands living deep within the interior of Alaska and Canada. Moreover, in searching the vast literature available online, the Inuit are by far the easiest to work with, as spellings have morphed only slightly over the last several centuries (e.g., Esquimeau, Esquimaux, Eskimos, Inuit). Names given to Northwest Coast groups are more complex and more varied, and those given to the countless bands of Athabaskan and Algonkian speakers spread across the interior of Alaska and Canada are a veritable nightmare, a bewildering array of referents and orthographies that make it exceedingly difficult to conduct a thorough search of the foodways of any one group.

The cumulative result of these many biases is a preponderance of examples derived from Inuit groups and a heavy focus on marine mammals and salmon. Interior groups are less well represented, with concomitantly fewer examples of the treatment of terrestrial resources like moose (*Alces*), caribou, and freshwater fish. In order to provide some semblance of balance in what follows, I decided to order the examples chronologically. This accomplished two things. First, it interdigitated examples from coast and interior, so that the reader does not come away with the mistaken view that preparing and eating putrefied meat and fish was largely a coastal phenomenon involving marine resources. And second, by ordering the examples from earliest to latest, one can see that putrefied meat and fish have been an integral part of northern cuisine from the time of first contact to the present, and remain highly valued symbols of the 'old' ways to this very day.

> "What knowledge they haue of God, or what Idol they adore, wee haue no perfect intelligence. I thincke them rather Anthropophagi, or deuourers of mans fleshe, then otherwise: for that there is no flesh or fishe, which they finde dead, (smell it neuer so filthily) but they will eate it, as they finde it, without any other dressing. A loathsome spectacle, either to the beholders, or hearers." (Settle 1577: not paginated)

> "They will, with so great an Appetite and Greediness, feed upon the rotten and stinking Seal Flesh, that it turns the Stomach of any hungry Man, who looks upon them." (Egede 1745: 135)

> "In Spring and Summer they catch a large Quantity of Fish, and digging Holes in the Ground, which they line with the Bark of Birch, they fill them with it, and cover the Holes over with Earth. As soon as they think the Fish is rotten and tender, they take out some of it, pour Water upon it, and boil it with red-hot Pebbles...and feed upon it, as the greatest Delicacy in the World. This Mess stinks so abominably, that the Russians who deal with them, and who are none of the most squeamish, are themselves not able to endure it." (Mueller 1761: ix)

> "[Feb. 13, 1780]—I was compelled by hunger to try some of the frozen venison of the Eskimos, for I had not a morsel of my own provision left. I was surprised to find how agreeable it tasted, although some of it had a rancid smell, having been killed in summer and remained ever since buried under stones. They had taken the skin off but left the intestines and paunch in the carcass. The Eskimos were extremely pleased to see that I could relish their meat, and said that I would suffer no hunger with them now as they had plenty of Mammuck—that is, stinking meat." (Taylor and Turner 1969: 145)

> "The most remarkable dish among them; as well as all the other tribes of Indians in those parts, both Northern and Southern, is blood mixed with the half-digested food which is found in the deer's [caribou's] stomach or paunch, and boiled up with a sufficient quantity of water, to make it of the consistence of pease-pottage. Some fat and scraps of tender flesh are also shred small and boiled with it. To render this dish more palatable, they have a method of mixing the blood with the contents of the stomach in the paunch itself, and hanging it up in the heat and smoke of the fire for several days; which puts the whole mass into a slate of fermentation...." (Hearne 1795: 316–317)

> "The stomach of no other large animal beside the deer [caribou] is eaten by any of the Indians that border on Hudson's Bay. In Winter, when the deer feed on fine white moss, the contents of the stomach is so much esteemed by them, that I have often seen them sit round a deer where it was killed, and eat it warm out of the paunch." (Hearne 1795: 317–318)

> "About twelve we also observed an Indian walking along the North-East shore, when the small canoes paddled towards him. We accordingly followed, and found three men, three women, and two children, who had been on an hunting expedition. They had some flesh of the reindeer, which they offered to us, but it was so rotten, as well as offensive to the smell, that we excused ourselves from accepting it." (Mackenzie 1814: 42)

> "Our hunters found their canoe and the fowl they had got, secreted in the woods; and soon after, the people themselves, whom they brought to the water side. Out of two hundred geese, we picked thirty-six which were eatable; the rest were putrid, and emitted a horrid stench. They had been killed some time without having been gutted, and in this state of loathsome rottenness, we have every reason to suppose they are eaten by the natives." (Mackenzie 1814: 86)

> "Several of them had bags of blubber, mixed with half-putrid half-frozen flesh; these they offered for sale with great eagerness, and appeared very much surprised that they got no purchasers. Being anxious to examine their contents, I was induced to buy one; on opening it, however, such a shocking stench proceeded from it, that I very cheerfully restored it to the original possessor. I had no sooner returned it to him, than applying the open extremity to his mouth, took a drink from it, licked his lips, and laid it aside very carefully." (M'Keevor 1819: 33)

> "When the Esquimaux visit us from the tent, they generally go to the spot where the carcases of the whales are left to rot after the blubber is taken, and carry away a part, but generally from the fin or the tail; they have been known, however, to take the maggots from the putrid carcase, and to boil them with train oil as a rich repast." (West 1824: 173)

> "The spawn of the salmon, which is a principal article of their provision; they take out, and without any other preparation, throw it into their tubs, where they leave it to stand and ferment, for though they frequently eat it fresh, they esteem it much more when it has acquired a strong taste, and one of the greatest favors they can confer on any person, is to invite him to eat *Quakamiss*, the name they give this food, though scarcely any thing can be more repugnant to a European palate, than it is in this state; and whenever they took it out of these large receptacles, which they are always careful to fill, such was the stench which it exhaled, on being moved, that it was almost impossible for me to abide it, even after habit, had in a great degree dulled the delicacy of my senses." (Jewitt 1849: 88)

> "...I have frequently known them when a whale has been driven ashore, bring pieces of it home with them in a state of offensiveness insupportable to any thing but a crow, and devour it with high relish, considering it as preferable to that which is fresh." (Jewitt 1849: 97)

> "Their manner of preserving their meat is quite characteristic. When an animal is killed the bowels are extracted, then the fore and hind quarters are cut off, and being placed inside the carcass, are secured by skewers of wood run through the flesh. The whole is then deposited under the nearest cleft of rock, and stones are built round so as to secure it from the depredations of wild animals until the hunters return to the coast; when the meat is in high flavour, and considered fit for the palate

of an Esquimaux epicure." (McLean 1849: 140)

"It is well known that both Esquimaux and Indians are very fond of the contents of the paunch of the rein-deer, particularly in the spring, when the vegetable substances on which the animal feeds are said to be sweeter tasted. I have often seen our hunter, Nibitabo, when he had shot a deer, cut open the stomach, and sup the contents with as much relish as a London alderman would a plate of turtle soup." (Rae 1850: 150)

"They [Carrier] all prefer their meat putrid, and frequently keep it until it smells so strong as to be disgusting. Parts of the salmon they bury under ground for two or three months to putrefy, and the more it is decayed the greater delicacy they consider it." (Wilkes 1851: 452)

"De la mi-juin à la mi-juillet, les *Tchiglit* se livrent à la pêche du hareng, du poisson blanc et de l'inconnu, dans les innombrables chenaux du Mackenzie. Ils conservent le poisson qu'ils ne consomment pas, soit en l'exposant à la fumée d'un petit feu, soit en le mettant en saumure dans des outres pleines d'huile de marsouin qu'ils suspendent à des arbres. Il ne se peut concevoir d'odeur semblable à celle qui s'exhale de ces vaisseaux, lorsque les Esquimaux les ouvrent pour en déguster le contenu. Toutefois, il m'a paru que ces poissons crus et rouges de fermentation doivent être un excellent mets, tant nos *Tchiglit* les mangent avec voracité." (Petitot 1876: 12)

"When these fish are caught, they are put into a seal-skin bag, and it remains tied up till the whole becomes a mass of putrid and fermenting fish, about as repulsive to taste, sight, and smell as can be imagined." (Kumlien 1879: 20)

"With an axe the rib pieces were soon severed from the back-bone, and then from the inside of these the natives cut strips with their sheath-knives, and handed me a chunky morsel from the loin, as breakfast. I bit into it without any ceremony, while the dogs clamored frantically for a share. So long as it remained frozen the meat did not exhibit the vile extent of its putridity; but directly I had taken it into my mouth it melted like butter, and at the same time gave off such a disgusting odor that I hastily relinquished my hold upon it, and the dogs captured it at a single gulp. The natives first stared in genuine astonishment to see me cast away such good food to the dogs, and then burst forth into hearty laughter at my squeamishness. But I was not to be outdone, much less ridiculed, by a Yakut, and so ordered some more, perhaps a pound of the stuff, cut up into little bits. These I swallowed like so many pills, and then gazed on my Yakut friends in triumph; but not long, for in a little while my stomach heated the decomposed mess, an intolerable gas arose and retched me, and again I abandoned my breakfast,—my loss, however, becoming the dogs' gain. At this the natives were nearly overcome with mirth; but I astonished them by my persistence, requesting a third dose, albeit the second one had teemed with maggots; and, swallowing the sickening bits as before, my stomach retained them out of pure exhaustion." (Melville and Phillips 1885: 226–227)

"But the 'loudest' feast of these savages consists of a box, just opened, of semi-rotten salmon-roe. Many of the Siwashes have a custom of collecting the ova, putting it into wooden boxes, and then burying it below high-water mark on the earthen flats above. When decomposition has taken place to a great extent, and the mass has a most penetrating and far-reaching 'funk,' then it is ready to be eaten and made merry over. The box is usually uncovered without removing it from its buried position; the eager savages all squat around it, and eat the contents with every indication on their hard faces of keen gastronomic delight—faugh!" (Elliott 1887: 56–57)

"Ikwa...returned in a jubilant frame of mind, and announced his discovery of a cached seal. He asked Mr. Peary if he might bring the seal to Redcliffe in the boat, saying it was the finest kind of eating for himself and family. We could not understand why this particular seal should be so much nicer than those he had at Redcliffe; but as he seemed very eager to have it, we gave him the desired permission, and off he started, saying that he would be back very soon. About half an hour later the air became filled with the most horrible stench it has ever been my misfortune to endure, and it grew worse and worse until at last we were forced to make an investigation. Going to the corner of the cliff, we came upon the Eskimo carrying upon his back an immense seal, which had every appearance of having been buried at least two years. Great fat maggots dropped from it at every step that Ikwa made, and the odor was really terrible. Mr. Peary told him that it was out of the question to put that thing in the boat; and, indeed, it was doubtful if we would not be obliged to hang the man himself overboard in order to disinfect and purify him. But this child of nature did not see the point, and was very angry at being obliged to leave his treasure. After he was through pouting, he told us that the more decayed the seal the finer the eating, and he could not understand why we should object. He thought the odor 'pe-uh-di-och-soah' (very good)." (Diebitsch-Peary 1894: 59–60)

"On one occasion I objected to some fish which an old man brought into the lodge as not being fresh enough, and made signs to that effect, chiefly with the aid of my nose. The old man went away and brought some more which were far worse. On these being rejected he beckoned me to come with him, and leading me to a swampy spot at the back of his *barrabora* pointed out what I took to be a newly made grave. I made signs of interrogation and deep sympathy, whereupon he scraped away the loose earth with a fish spear and lifted a board which covered the top of the pit. I fully expected to see the body of a dearly beloved relative, and experienced nearly as great a shock when I found the pit was filled to the brim with a seething mass of rotten salmon. The old fellow's next signs I fully understood; they were to the effect that if I wanted something really good I must give him more than the usual amount of tobacco leaves, and I began to realise that he had misunderstood my sign language and thought I was objecting to his fish because they were too fresh." (Pike 1896: 258)

"Some of them [Big Bellies] invited us to their huts to eat, in expectation of receiving a bit of tobacco, but we found it impossible to taste their dried meat; it was so nearly putrid that the pieces would scarcely hold together. This, however, is entirely to their liking; they seldom use meat till it is rotten; they keep it in their huts, unexposed to the air, till it is almost impossible for a stranger to remain indoors on account of the stench arising from putrefaction." (Coues 1897: 356–357)

"The chief delight of the Indians is in the parts of the fish that are usually discarded by white people. For instance, they line a pit with the big leaves of the skunk cabbage, which grow here to enormous size. Then they fill the space with the heads of the hump-backed salmon, and, lining the top over nicely with more skunk cabbage leaves, they cover it all over with dirt. Now this would be a very commendable way of disposing of the salmon heads if they were satisfied to leave them covered up, but they are not. After about six weeks they give a grand potlatch, which continues as long as this delicate and artistic creation holds out." (Maris 1897: 6)

"Meat is frequently kept for a considerable length of time and some times until it becomes semiputrid. At Point Barrow, in the middle of August, 1881, the people still had the carcasses of deer which had been killed the preceding winter and spring. This meat was kept in small underground pits, which the frozen subsoil rendered cold, but not cold enough to prevent a bluish fungus growth which completely covered the carcasses of the animals and the walls of the storerooms." (Nelson 1899: 267)

"In the district between the Yukon and the Kuskokwim, the heads of king salmon, taken in summer, are placed in small pits in the ground surrounded by straw and covered with turf. They are kept there during summer and in the autumn have decayed until even the bones have become of the same consistency as the general mass. They are then taken out and kneaded in a wooden tray until they form a pasty compound and are eaten as a favorite dish by some of the people. The odor of this mess is almost unendurable to one not accustomed to it, and is even too strong for the stomachs of many of the Eskimo." (Nelson 1899: 267)

"Their food is largely salmon, though seal, beluga, and walrus also enter their diet when they can be obtained, and occasionally a deer or moose is taken. Their food is all preferred 'high'—not high in the sense of the epicure, but rotten; rancid oil is generally cooked with it or used for sauce. The decaying carcass of a whale cast on the beach attracts the natives for many miles, and a grand feast is held over it; rotten salmon heads are a *bonne bouche*." (Moser 1902: 178)

"As soon as the salmon come into this lake, they go in search of the rivers and brooks, that fall into it; and these streams they ascend so far as there is water to enable them to swim; and when they can proceed no farther up, they remain there and die. None were ever seen to descend these streams. They are found dead in such numbers, in some places, as to infect the atmosphere, with a terrible stench, for a considerable distance round. But, even when they are in a putrefied state, the Natives frequently gather them up and eat them, apparently, with as great a relish, as if they were fresh." (Harmon 1903: 171)

"The Carriers cut off the heads of salmon, and throw them into the lake, where they permit them to remain a month, or at least until they become putrefied. They then take them out, and put them into a trough, made of bark, filled with water. Into this trough they put a sufficiency of heated stones, to make the water boil for a time, which will cause the oil to come out of the heads of the salmon, and rise to the top of the water. This they skim off, and put into bottles made of salmon skins; and they eat it with their berries. Its smell however is very disagreeable; and no people would think of eating it excepting the Carriers." (Harmon 1903: 284)

"Although it would be easy to construct storerooms in the frozen ground, in which meat could be preserved in good condition, the Chukchee are satisfied with their ill-protected cellars, in which the provisions soon begin to become putrid. Therefore both the Reindeer and the Maritime Chukchee live on putrid meat throughout the summer and part of the winter." (Bogoras 1904: 195)

"When the Reindeer people drive their herds to the summer pastures, ten or fifteen animals are slaughtered for summer provisions. The meat is simply hung in the tent, where it is easily accessible to carrion-flies and other insects. After several days it is placed in a pit dug in the centre of the tent, and covered with sod. Later on, when the pit is opened, the stench is so strong that it is disagreeable to the natives themselves, who avoid staying in the tent until the pit is covered over again." (Bogoras 1904: 195)

"Among the upper tribes, particularly among the Déné, where the salmon are not taken in such quantities as nearer the mouth of the Fraser, the heads are always carefully preserved for making oil. They are strung on willow rods and deposited in the water on some sandy shore of the lake or stream, where they remain till they have reached an advanced stage of decay. When 'ripe' they are gathered up and placed in large trough-like receptacles, and boiled by means of the usual heating-stones. During the boiling the oil rises from them to the surface and is skimmed off into birch-bark buckets, and afterwards stored away in bottles made from the whole skins of the salmon." (Hill-Tout 1907: 94–95)

"We travelled on till 5.30 that evening, and camped under a conspicuous hill at what is called by the natives 'The Canoe Portage.' Here the dogs started off at a run, much to our surprise, making us think that a bear or some deer were in the neighborhood; but this was not the case: they had scented a dead whale, which must have been on the coast for five years at least, and soon proceeded to dig under the snow. The natives took them out of their harness, and proceeded to put up the tents, not knowing what was buried there. While this was being done the dogs made several holes down in the snow, and tried in vain to tear away some portion of blubber or meat from the carcass. The natives soon got to work with their knives, and cut off great quantities of putrid flesh, which, though frozen, stunk with so bad an odour that I found it most repulsive; they then proceeded to eat great quantities of it, and seemed to enjoy it as much as the dogs did. I could not join in this feast, but retired into my tent to enjoy a meal of tea, which greatly refreshed me." (Harrison 1908: 241–242)

"The Carriers had other delicacies, among which half putrid salmon roe and a most stinking oil extracted from the same fish held a prominent place. The wayfarer through their country cannot help observing the many cavities, evidently of an artificial origin, that dot the immediate vicinity of their streams or the outskirts of their ancient village sites. They are the pits wherein the fish roe was formerly deposited and covered up with earth for a twelvemonth or so. At the expiration of that time, it was considered sufficiently done, and consumed, raw or cooked, generally with preserved berries. In this advanced stage of putrefaction it was deemed the most dainty morsel imaginable, though Harmon is inconsiderate enough to declare that it then fills the air with a terrible stench, and even to a considerable distance. This is certainly true of their nasty fish oil, and I heartily concur in his statement that 'a person who eats this food, and rubs salmon oil in his hands, can be smelt in warm weather, to a distance of nearly a quarter of a mile'." (Morice 1909: 597)

"In eating raw fish today, only slightly high, I could barely smell it in the tent, Anderson (Kotzebue) had to go out and throw up what he had eaten, at which the other five (some Kogmollik, some Nunatama) who were eating in our tent laughed very much. When he came back he told me that his people never eat raw fish unless it is well rotted. The Kogmollik and Nunatama prefer it a little rotten, but are fond of it in all stages from fresh from the net to a cheesy consistency. His people bury fish in the ground to rot it." (Stefansson 1914: 160)

"The Arctic 'salad,' which seems to be favoured more in winter, when no vegetable food has been seen for months, is the first stomach or rumen of the caribou when it happens to be filled with freshly-chewed reindeer-moss or *Cladonia* lichens. This is frozen whole and sliced off very thin, the gastric juice supplying the acid, and a liberal mixture of seal-oil the salad dressing. The caribou stomach is seldom eaten except when filled with the succulent reindeer-moss, and when it contains woody grass-fibre is usually discarded. This food may properly be classed as 'pre-digested,' and under certain extenuating circumstances, such as a trail appetite, a long siege of one-course rations of meat, anything 'different' may have some attractions, but few white men venture to experiment with it." (Anderson 1918: 64)

"Usually, when parties leave for the summer deer hunting, the old people and some of the children stay at the tide water at the mouth of a good salmon river, and put all the fish they take under piles of rocks. The earlier caught become very soft and rotten, and are used in winter as dog feed, though the natives enjoy a feed of this 'for a change,' just as they do rotten walrus or seal meat, which in white nostrils smells to high heaven." (Munn 1922: 271)

"...*lann* = Fleisch, das im Wasser aufbewahrt worden ist, vor allem Wildrenfleisch im Sommer. Dadurch hat das Fleisch einen säuerlichen Geschmack erhalten und wurde als eine Leckerei angesehen." [...*lann* = Meat that has been kept in the water, especially wild meat in the summer. This has given the meat a sour taste and has been regarded as a treat.] (Väinö Tanner [1928]; cited in Pohlhausen 1953: 988; English translation mine)

"Right alongside the spot where we pitched our camp we found an old cache of caribou meat—two years old I was told. We cleared the stones away and fed the dogs, for it is law in this country that as soon as a cache is more than a winter and a summer old, it falls to the one who has use for it. The meat was green with age, and when we made a cut in it, it was like the bursting of a boil, so full of great white maggots was it. To my horror my companions scooped out handfuls of the crawling things and ate them with evident relish. I criticised their taste, but they laughed at me and said, not illogically: 'You yourself like caribou meat, and what are these maggots but live caribou meat? They taste just the same as the meat and are refreshing to the mouth.'" (Rasmussen 1931: 60)

"In the beginning of my educational and medical service among the western Eskimos I witnessed them eating such rotten foods as would kill a white man in short order. When they began digging their vitiated surplus meats from the caches and snow banks, when their diet consisted of rotten fish and rancid fat, I would suffer many qualms as to the probable outcome. Invariably I would provide my medicine kit with items for combating and treating ptomaine poison, and always, to my utter astonishment, they would eat those rotten poisonous foods and thrive on them. Lest the reader might think that the cooking process would destroy the poisons in their vitiated foods, I wish to say that in only a few instances did they cook their food." (Garber 1938: 245)

"Caribou meat and fish are eaten raw, and are preferred when they are rotten; caribou and fish heads are boiled. The caribou liver is allowed to ferment inside the moss-filled caribou stomach under a hot sun for some days before being eaten...." (Sinclair 1953: 72)

"Decayed fish were not eaten during the warm weather; they were not considered good until frozen. As soon as the freeze-up came, they began to be used as delicacies, sometimes as whole meals. The only way of serving decayed fish was to allow them to thaw in the house until they were as soft as hard ice cream, when they were eaten somewhat as a child would consume an ice cream cone." (Stefansson 1960: 36)

"A delicacy for them [Nganasan] was the meat of wild reindeer that had been left for a time where they were caught without being disemboweled. Such meat soon became putrid and had an unpleasant taste...." (Popov 1966: 111)

"...in autumn the Karelians buried wild reindeer meat in a swamp and left it there until winter came...and the Kola Lapps threw young reindeer into a lake or river, where they were left until they had a slightly 'bad smell'." (Eidlitz 1969: 108)

"Interviews with 12 elderly Yupik [Inuit] indicated that fish heads were traditionally fermented in clay pits dug in the ground; families used the same pit each year.... The Athabascans [non-Inuit Native Americans] ferment fish by floating a string of fish heads in the river for one to two weeks." (Shaffer et al. 1990: 392; see also Wainwright 1993: 316)

"We now saw these people again at their own village, and what a smelly place it was!—racks and racks of dried fish, hundreds of salmon heads strung up, and sacks full of salmon eggs rotting and oozing out. They buried these eggs in pits to keep for dog feed in the winter, they told us, but I believe this was to ferment them for human consumption, just as we process and enjoy certain strong cheeses. Since the Indians were sensitive to possible ridicule from white people, these people probably wanted us to think that this smelly treat was only for the dogs. The last year's pits were open and full of putrid water and maggots." (de Laguna 2000: 287)

"The walrus is a valued source of traditional food, prized for its meat which is often fermented for several months inside the skin of the walrus buried in the ground." (Fediuk 2000: 54)

"Along the Arctic shore, Fermented Stink Heads were made by digging a hole in the sand and lining it with acidic leaves. Ideally, the hole was filled with salmon heads and one- or two-day-old salmon eggs, preferably from vigorous humpies or pinks caught on their way upriver to the spawning grounds. The heads were either individually wrapped or simply layered with wild celery leaves and/or dried eelgrass. They were then covered with more acidic leaves and topped with wood or dirt, and the contents left to ripen for two weeks to two months." (Spray 2002: 38)

"The second method for procuring fermented foods was as a by-product of hunting. Herbivorous animals frequently ate lichens and grasses toxic to humans, but after the plants had decomposed or fermented in the animal's stomach, aided by the acidic digestive juices, the stomach contents were perfectly safe for human consumption. These naturally fermented foods came from the stomachs of freshly killed moose and caribou, or from ptarmigan intestines. With a slightly sweet, earthy taste, they were a hunter's reward, and very welcome." (Spray 2002: 38)

"...the owner also kept fish heads under water by hanging them on a line attached to the cutting table, one step in preparing a fermented fish dish commonly called 'stink heads.'" (Fall et al. 2010: 61)

POND STORAGE: THE DANIEL FISHER EXPERIMENTS

The ethnohistoric and ethnographic literature clearly shows that meat and fish can be preserved for many months by fermentation and putrefaction. Two of the technologically least complex and most widely used approaches were to bury the food in a shallow pit or immerse it in a bog, lake, or river. And while in both types of storage putrefaction of the final product was often so advanced that it was viewed by Westerners as disgusting and probably dangerous to eat, such foods in fact were not only free of serious pathogens, but were highly esteemed by the foragers who depended on them.

From the examples highlighted above, one might easily come away with the impression that storage of meat and fish by putrefaction only works in arctic and subarctic environments. However, the many references provided earlier show that rotted meat also was frequently eaten by Hadza, San (Bushmen), Maori, and other hunter-gatherers across a wide range of habitats and environments, and done so with a degree of gusto and impunity not unlike what we have seen among Inuit and their boreal forest neighbors. I think the major reason such techniques are so prominent in the northlands stems from the fact that they provide a low-cost solution to problems that are especially critical in the higher latitudes: (1) they reduce the high metabolic costs of an all-meat diet by softening the food and 'pre-digesting' the protein and fat without the need for cooking and hence without the need for scarce fuel; (2) they allow fatty meat and fish to be effectively preserved for long periods of time in areas where frequent damp, cloudy, or rainy weather precludes rapid and thorough drying of fatty meat and fish; and, (3) they offer a means of preserving critical vitamins, especially vitamin C, that are not available from other types of foods such as fruits and vegetables, and that would otherwise be degraded or lost through cooking, as well as through traditional methods of food storage such as drying and smoking.

That deliberately putrefied meat can provide healthy nourishment, with little or no fear of infection from pathogenic bacteria, far beyond the arctic and subarctic has been clearly demonstrated by a unique set of experiments carried out in the state of Michigan (USA) by Daniel Fisher (1995), a paleontologist at the University of Michigan in Ann Arbor. Fisher began his experiments by caching mostly small, uncooked leg units of lamb during the fall of 1989 in shallow ponds and bogs in the southern part of the state. This part of the Midwestern USA is characterized by hot humid summers (average high in July: 28°C/83°F) and short, moderately cold winters (average low in January: –8°C/18°F). Given Fisher's ultimate interest in late Pleistocene megafaunal extinctions, he decided to expand these initial experiments to look at the feasibility of storing meat from a much larger animal under water. Thus, in the early 1990s he began pond-caching partially disarticulated carcass units of a 680 kg (1,500 lb) draft horse. He put these units into a shallow pond during the winter by inserting them through holes chopped in the ice, and then anchored them to the bottom using sediment-filled intestines. At regular intervals he collected representative samples of meat and checked them for odor, physical condition, and bacterial content.

The results of these experiments are very informative. The meat retained an essentially fresh appearance, with low total bacterial counts, until spring, when it began to turn more acidic and distinctly 'cheesy' smelling. Fisher attributes the change to increasing activity of lactic acid bacteria (LAB), particularly members of the lactobacilli. By April, algae began to cover the exterior of the butchery units, but beneath the outermost surface both meat and fat were still entirely edible, though sour-smelling. The meat became increasingly 'cheesy' and sour-tasting by June, but remained free of pathogens. Finally, in July and August the meat, while still safe to eat, began to disintegrate. Needless-to-say, disintegration, and hence loss of meat, posed less of an issue for the carcass units that Fisher cached in bog settings, and I would imagine that the same would be true for meat cached in below-ground pits.

The take-away message from Fisher's experiments is that 'pond storage' (i.e., storage in water, whether in a bog, pond, lake, or river) is a relatively low-tech, yet safe way of caching meat and fish at strategic points on the landscape, one that can be used over a wide range of environments, including regions far removed from the arctic and subarctic, and over much of the year, not just in winter when the pond or river is covered over by ice.

THE DISGUST RESPONSE

Judging by the countless ethnohistoric and ethnographic descriptions of the relish with which hunter-gatherers—especially in the northern latitudes, but in many other parts of the globe as well—ate putrid meat, fish, and fat, it seems quite clear that the intense disgust that Euroamerican adults typically display to both the odor and sight of such foods (revulsion, nausea, facial expressions of disgust) is in large measure a culturally learned response, not a human universal that comes hard-wired in all of us at birth. In fact, a large number of studies, beginning with the classic work of psychologist Paul Rozin, show that children probably do not begin to acquire the classic disgust responses that we associate with the sight and smell of rotten and maggoty meat until as late as the age of five or even later (see Herz 2012: 46–47; Rozin et al. 2008: 765; Widen and Russell 2010). And up to at least the age of seven children commonly misinterpret as anger the adult facial expressions connected with disgust (Widen and Russell 2010).

Anthony Synnott (1991) takes an interesting look at the issue of smell from a sociological perspective, providing a fascinating and wide-ranging overview of the many subtle and complex ways in which our perceptions of odors—good versus bad, pleasing versus foul—have come to be inextricably interwoven into the very fabric of our culture, playing fundamental roles in demarcating and maintaining ethnic identities, economic statuses and social classes, racial categories, moral and ethical valuations, and numerous other aspects of our day-to-day economic and social lives. Such studies make it clear that we learn the disgust response to substances like rotten meat, we are not born with it. It should come as no surprise, then, that children in traditional arctic and subarctic foraging societies were brought up with a set of cultural values very different from our own, ones in which their taste and smell preferences were closely and compatibly aligned with foodways that were nutritionally sound, energetically realistic, and fuel-sparing in resource-poor high-latitude environments that were arguably among the most difficult ones on the planet for members of our species to successfully colonize.

The results of these studies are interesting from an evolutionary perspective. If the disgust response to a substance like rotten meat is not fully in place at the time of weaning, a young child's point of greatest vulnerability to orally introduced vectors of diarrheal and other diseases, this calls into question the conventional wisdom that the disgust response evolved as a way to protect the youngster from putting pathogenic substances in his or her mouth (Rottman 2014). It is also important to keep in mind that the sharp upswing in botulism cases in the arctic since the 1970s and 1980s is largely an outcome, not of traditional methods of rotting foods in pits, bogs, lakes, and seal pokes, but of the introduction by Euroamericans of supposedly more 'hygienic' means of fermenting these foods using sealed glass bottles and plastic bags placed in more 'sanitary' (and often above-ground) locales. Bottom line: for hunters and gatherers living unacculturated lifestyles, contamination of rotted meat and fish by pathogenic bacteria seems not to have posed much of a health hazard, and for children raised in the traditional foodways of their culture, the smell would have been largely if not entirely irrelevant. As a 19th-century Inuit informant put it: 'we don't eat the smell' (Fienup-Riordan 1988: 11).

There is one thing that has become strikingly clear in attempting to pull together the many threads that form the heart of this paper. Regardless of disciplinary focus, be it modeling early hominin scavenging in archaeology, or evaluating the safety and acceptability of fermented sausages in the food sciences, or attempting to account for the origin and function of the disgust response in psychology, specialists in these and other fields commonly operate with the same basic underlying assumption—that putrid meat is inherently unsafe to eat because of the (presumed) toxicity created by pathogens such as *Clostridium botulinum*. One can see the power and pervasiveness of this assumption in the opening paragraph of a fairly recent article on the microbiome of New World vultures (Roggenbuck et al. 2014). Citing but a single reference for support (Reed and Rocke 1992), one that is focused heavily on recent outbreaks of botulism in waterfowl, these authors draw the sweeping generalization that:

> "The microbiota of vertebrates rapidly begin to decompose their hosts after death. During the subsequent breakdown of tissue, these microorganisms excrete toxic metabolites, rapidly rendering the carcass a hazardous food source for most carnivorous and omnivorous animals." (Roggenbuck et al. 2014: 1)

The hunter-gatherer literature clearly shows this sort of blanket assertion to be false. If this paper has accomplished nothing else, the reader should at least by now be convinced that rotten meat, even meat that reeks and is filled with maggots, may nonetheless be entirely safe to eat, and that even in an advanced state of decay such meat is (or was until recently) viewed by many traditional foraging peoples as a very desirable food. In short, just because meat is rotten does not automatically mean it is hazardous. The toxicity of a decomposing carcass must be demonstrated, not assumed.

Despite the hunter-gatherer evidence, not to mention the tremendous advances in the fields of nutrition, food science, and microbiology, the biases expressed in Roggenbuck et al.'s (2014: 1) opening paragraph remain steadfastly entrenched. Nothing exposes the tenacity of this bias more clearly than the work of William Savage (1921: 83), who nearly a century ago conducted a series of experiments in which he fed putrid meat to kittens. Though his results were not entirely concordant, Savage concluded that 'a study of the evidence...singularly fails to bring forward any evidence associating the consumption of food in a state of incipient putrefaction with illness in those who consume it.'

Concerning the massive outbreaks of botulism in water birds cited by Reed and Rocke (1992), there is a growing body of literature implicating pollution and eutrophication of water bodies as likely sources of the problem, with toxic algal blooms, nitrate-rich runoff from surrounding farmlands, contamination by sewage and garbage, and use of effluent from wastewater treatment plants to re-establish wetlands emerging as prime suspects (Anza et al. 2014; Murphy et al. 2000). It is a mistake to jump from these altered and often polluted circumstances to the universal generalization that rotten meat, at all times and in all places, is inherently dangerous.

But this is not to deny that botulism can at times be a very serious problem. Hence, what we need is a better understanding of the specific constellation of circumstances in which meat on a decaying carcass remains safe to eat (setting aside cultural preferences of taste and smell), versus the conditions in which such meat is likely to become laced with potentially deadly pathogens. The latter is clearly not an inevitable outcome. Moreover, judging from ethnohistoric and ethnographic sources, contamination by pathogens is not even the inevitable outcome of decomposition in warmer climes. This is shown by reports of hunter-gatherers and small-scale subsistence farmers in many parts of sub-Saharan Africa consuming very 'ripe' meat, as for example the putrid meat and blubber retrieved by Bushmen (San) from beached whale carcasses along the Namibian and South African coast, or the rotten meat scavenged by Hadza from lion kills in Tanzania. Thus, there is a real need for further research to help identify the specific constellation of temperature, humidity, air circulation, exposure, and condition of the carcass, as well as the health and physical condition of the animals themselves before they died, that together would foster the proliferation of *Clostridium botulinum* spores in putrefying carcasses.

In any case, our revulsion at the sight and smell of rotten meat, and our steadfast belief that such meat is hazardous, are very likely the offspring of our own Eurocentric cultural biases. These biases are reinforced by our lack of first-hand experience as subsistence hunters, and are passed on from generation to generation as a form of inherited wisdom, kept alive, despite our training as scientists, by our failure to look beyond cultures and contexts that fit comfortably within our own familiar value systems. It is a cultural bias, whether applied to human foodways or to the dietary habits of vultures, a bias that would be easier to recognize and address if there were more effective cross-disciplinary communication.

I am definitely not suggesting that humans are lacking in any sort of universal *capacity* to react to unpleasant elicitors with a response that psychologists would classify as *disgust*. There certainly seems to be no shortage of literature suggesting that they do. What I am questioning here is the supposed universality of the *elicitors* of such responses, even the so-called 'core' elicitors (Rozin et al. 1999: 433), not the capacity itself. As we have already discussed at length, the sight and smell of putrid, maggoty meat and fish are clearly not universally viewed as disgusting. But other 'core' disgust elicitors which psychologists often treat as though they were universal—the sight, touch, and smell of feces and urine being prime examples—are just as culturally contingent as putrid meat, as a perusal of the cross-cultural ethnohistoric literature quickly shows.

Looking first at feces, what immediately comes to mind are the classic observations of Johann Jakob Baegert, a Jesuit priest who served for 17 years (1751–1768) as a missionary among the hunter-gatherers of Baja California. I think it fair to say that Baegert was genuinely disgusted by the natives' habit, not just of touching their own feces, but of systematically collecting them in order to retrieve and consume the abundant tiny seeds that had passed undigested through their system after ingesting large quantities of pitahaya (cactus) fruit:

> "...I mentioned that the pitahayas contain a great many small seeds, resembling grains of powder, which for reasons unknown to me are not consumed in the stomach but passed in an undigested state. In order to use these small grains, the Indians collect all excrement during the season of the pitahayas, pick out these seeds from it, roast, grind, and eat them with much joking. This procedure is called by the Spaniards the after or second harvest! Whether all this happens because of want, voracity, or out of love for the pitahayas, I leave undecided. All three surmises are plausible and any one of them might cause them to indulge in such filthiness. It was difficult for me, indeed, to give credit to such a report until I had repeatedly witnessed this procedure." (Baegert 1952: 68; for the original German text, see Baegert 1773: 119–120)

Homer Aschmann (1959: 77) provides additional details about the 'second harvest' in Baja California, noting that other Jesuits, not just Baegert, had observed—apparently with equal disgust—this native practice, and that at least one unsuspecting early missionary to the region—Father Francesco María Piccolo—had inadvertently eaten seeds obtained in this manner.

Prehistoric pits filled with human feces (coprolites) have been found in a number of dry caves in the Great Basin of the western United States. David Thomas (1985: 380–381) discusses these so-called 'latrines' at length, noting that in at least some cases such deliberate fecal accumulations occur together with caches of equipment that had clearly been stored in the caves in anticipation of future use. To Thomas, the placement of the latrines side-by-side with other cached items suggests that the feces had also been stored there, presumably as food reserves for future use—in short, additional examples of Baegert's 'second harvest.'

Arctic groups provide additional insights into forager attitudes toward excrement, and show no evidence, at least in these contexts, that feces necessarily elicited feelings of disgust, whether through direct contact or by indirect contamination of other items or foods.

> "The use of ptarmigan droppings appears to be limited to a few groups of Eskimos. According to Mathiassen..., 'Ptarmigan excrement is chewed together with walrus meat into a porridgy mass which is stirred up in blubber.' Similarly, the Netsilik Eskimos are said by Birket-Smith...to have used 'ptarmigan excrement mixed with blubber and chewed meat'." (Eidlitz 1969: 88)

> "Certain remarks and deeds of Pannigabluk's today prompt me to enter certain things about Eskimo cleanliness, etc. Pan. [Pannigabluk] will clean dog excrement off a sole of a pair of boots with her ulu [knife], wipe it casually with a rag that may have had as bad uses a dozen times before, and then proceed to eat with the ulu or cut up with it food for cooking...." (Stefansson 1914: 226)

The Hadza of Tanzania provide yet another example of humans freely handling feces with no evidence whatsoever that seeing, smelling, or touching them elicited any sort of disgust response:

> "Baobab seed is also a good protein source with adequate levels of five out of eight essential amino acids.... The Hadza chew young seeds; but when mature, the seeds are cracked individually with a stone or pounded into a coarse flour.... Baboons, which have teeth well-shaped for seed cracking...cannot break the mature seeds and pass them unbroken. Hadza women collect baobab seeds from baboon dung piles, wash them, and prepare them in the normal manner...." (Schoeninger et al. 2001: 182)

Throughout much of Southwest and South Asia, manure from cattle, sheep, and other livestock is systematically gathered, kneaded into dung cakes, dried, and stored in and around the house where it serves as an important fuel for cooking and warmth, a component of household architecture, and at times may even be ingested in some form for medicinal purposes.

> "Only the dung of the zebu cow was used to plaster the stove and the kitchen area.... For fuel, dung was molded into relatively flat round cakes which were dried in the sun. Each family had a special place where dung cakes were made and stored.... The women of a family...daily carried dung dropped by the family cattle to this place. Families who owned no cattle collected dung from the village lanes and the grazing area. Traditionally, such dung was available to everyone and it was collected by most families. One important duty of a young daughter was to go early every morning through the village lanes to mark dung that fell from cattle when they were driven to the pond or to the grazing area and later to collect it... One morning we watched a woman from an 11-person family making dung cakes.... She mixed the dung with small pieces of mustard stalks, kneaded it, and formed it into cakes of two sizes which she spread on the ground to dry. In the course of the morning, she made about 24 large cakes and 103 small ones." (Freed and Freed 1978: 80–81)

> "In Iran manure is an especially valued and carefully treated commodity. Rural and urban communities use it to fertilize the soil, produce energy (burning), eradicate pests and plant diseases, make bricks and plaster walls. In some cases it is also used to treat human illness.... For example, the dung of newly born foals mixed with the milk of lactating donkeys is used in some villages to treat whooping cough.... Iranian villagers...utilize animal manure and bird droppings as a source of energy. In some rural areas animal manure is still used to generate heat and women believe that the best fire for baking bread is one made from animal droppings because it produces more uniformly baked and thoroughly toasted bread." (Ardakani and Emadi 2004: 13)

As a final example, the Chinese have a long history of using human feces ('night soil') as manure in their agricultural fields. Not surprisingly, there is no hint that either the sight or smell of night soil elicited anything resembling a disgust response in the country's rural inhabitants:

> "For crops in a vigorous growing state no kind of manure is so eagerly sought after as night soil; and every traveller in China has remarked the large cisterns or earthen tubs which are placed in the most conspicuous and convenient situation for the reception of this kind of manure. What would be considered an intolerable nuisance in every civilised town in Europe, is here looked upon by all classes, rich and poor, with the utmost complacency; and I am convinced that nothing would astonish a Chinaman more, than hearing any one complain of the stench which is continually rising from these manure tanks.... In England it is generally supposed that the Chinese carry the night soil and urine to these tanks, and leave it there to undergo fermentation, before they apply it to the land. This, however, is not the case; at least, not generally. In the fertile agricultural districts in the north, I have observed that the greater part of this stimulant is used in a fresh state, being of course sufficiently diluted with water before it is applied to the crops." (Fortune 1847: 314–315)

Another favorite in the list of supposed 'core' universal disgust elicitors—urine—is also effectively demolished by the cross-cultural ethnographic record and, as in the case of putrid meat, the damning evidence again comes from the Inuit. Urine was their principal 'soap'!

> "Urine...is collected from the containers in the men's house only (since that of women is believed to be unclean), to be stored in tubs for at least two days before using. Women...first bathe in urine, followed by a rinsing in either salt or fresh water. Both sexes frequently wash hands and faces in urine, and rinse with water; for urine, coming into contact with the body oils, acts as soap in removing grease and other impurities. The men, when about to take a sweat-bath...gather in the men's house. There the floor boards are removed and a roaring fire built in the pit.... The participants, soon drenched with perspiration, bathe themselves with urine from the central pot...." (Curtis 1930: 43)

So, it would seem from the studies by Rozin et al. (2008), Rottman (2014) and others, together with the comparative insights drawn from the ethnographic literature, that the search for universal disgust *elicitors* may be doomed from the outset, because the entire endeavor is based upon what is likely to be a false assumption, namely that the disgust response is a product of natural selection which serves to protect infants from putting bad things in their mouth. As Liberman and colleagues (2016: 9480) put it: '...human infants are surprisingly inept at categorizing and selecting appropriate foods.' Instead, these authors propose a very different type of explanatory framework for the way infants come to distinguish those foods that are acceptable and appropriate (hence 'good to eat') from those that are inappropriate, perhaps even disgusting (hence 'bad to eat'). In their view such distinctions derive, not from intrinsic health-related or nutritional properties of the foods themselves, but from prosocial cues the infants receive from their caregivers and from others in their close social network who engage positively with each other and, importantly, *who speak the same language*. In other words, from this perspective *elicitors* of the disgust response are just part of a broad suite of culturally contingent markers that serve to identify socially meaningful groups of people who share a common set of values and beliefs, while simultaneously creating boundaries that differentiate such groups from culturally more distant 'others' (for a surprisingly early exposition of the culturally relative nature of people's perceptions of what does or does not 'stink,' see Smollett 1785: 13–14). This culturally nuanced perspective would seem to fit ethnographic reality far better than traditional pathogen-based explanations.

SCHOENINGEN: LATE MIDDLE PLEISTOCENE POND STORAGE?

Let us turn now to the most speculative part of this already quite speculative endeavor. Did hunter-gatherers already in the Paleolithic also make use of fermented or more thoroughly rotted meat? My answer to this question is a very tentative 'maybe.' There are a number of potential candidates in the literature, all cases in which foragers may have cached partly butchered carcasses under water in a bog, lake, or river. The earliest of these, and the one which I will discuss in some detail below, is the late Middle Pleistocene German site of Schoeningen (Schöningen). Two other noteworthy candidates, also in Germany but much younger than Schoeningen, are the very late Upper Paleolithic Hamburgian and Ahrensburgian reindeer kill sites of Meiendorf and Stellmoor (Rust 1937, 1943; see also Price et al. 2017). At both of these localities, but perhaps most dramatically seen in the Ahrensburgian layers at Stellmoor, large numbers of reindeer carcasses, some complete or nearly so, many as partly butchered units, were placed in the water, some apparently deliberately anchored to the bottom with rocks. Not surprisingly, controversy swirls around the interpretation of these two sites, with some authors favoring deliberate underwater storage of reindeer meat (see Chatterton 2005: 68 and especially Grøn 2005: 21); others championing alternative though not necessarily mutually exclusive explanations, such as kills that were simply abandoned because they were not needed or because the animals were in poor condition, or carcasses that were placed in the water as ritual offerings, or discarded waste from shore-based butchery activities (e.g., Bokelmann 1979, 1991; Bratlund 1996; Grønnow 1987; Pohlhausen 1953; Rust 1937, 1943).

The site of Schoeningen, located about 100km (62mi) east of Hanover, Germany, is one of the most interesting and important Paleolithic sites in western Europe. Consisting of numerous separate localities exposed by open-cast lignite mining, Schoeningen is perhaps best known for the so-called 'Horse Butchery Site' or 'Spear Horizon,' designated officially as Schö 13 II-4. This locality, dated around 310 ky and attributed to the latter or deteriorating stages of the late Middle Pleistocene Reinsdorf Interglacial (MIS 9), has so far produced nine wooden-tipped spears and one lance, as well as numerous other miscellaneous wooden items, many thousands of animal bones, the majority representing some 45–50 very large (~550kg) horses (*Equus mosbachensis*), and a modest lithic assemblage consisting mostly of flakes and debitage, and small numbers of formal tools such as scrapers. Handaxes and Levallois technique are noteworthy for their absence. Most assign the site to the late Lower Paleolithic, although it could easily be considered an early Middle Paleolithic site. As to the hominin responsible, opinions differ, some suggesting the occupants belonged to the taxon *Homo heidelbergensis*, others seeing Schoeningen as an early Neanderthal manifestation (Conard et al. 2015; Jöris and Baales 2003; Richter and Krbetschek 2015; Schoch et al. 2015; Serangeli et al. 2015; Urban and Bigga 2015; van Kolfschoten 2014; van Kolfschoten et al. 2012).

There is general agreement that the primary focus of activities at Schö 13 II-4 was the killing, butchering, and processing of horses, and that the site's location right on the margin of a shallow lake would not have been well suited as a primary camping spot. Moreover, earlier claims for hearths at the site have been rejected, further supporting the idea that Schö 13 II-4 was a functionally specific hunting-butchering locale rather than a longer-term campsite.

There is less agreement about how the horses were killed. Until recently it was believed that the animals had been driven *en masse* into the lake or a muddy or swampy area along its borders (Thieme 2005: 130; Voormolen 2008). However, more recent evidence—stable isotopes, dental wear patterns, and age-sex data—all converge to suggest that the accumulation of horse remains is more likely the product of multiple events involving different herds and perhaps taking place at somewhat different times of year (Conard et al. 2015; Julien et al. 2015; Rivals et al. 2015).

None of this evidence by itself necessarily points to pond storage. Countless Paleolithic sites occur in lake shore settings, so finding a similar situation at Schoeningen at first glance would not seem the least bit unusual. The surprise came from the detailed studies of the sediments and associated microfossils which encased the bones, in combination with trace evidence found on the surfaces of the bones themselves. According to Stahlschmidt and colleagues (2015: 83), 'the micromorphological, FTIR, and organic petrology results of the investigated profiles indicate that all three sedimentary layers associated with archaeological remains...formed under permanent water coverage....' These authors go on to conclude that 'the sediments directly associated with the archaeological finds...show no signs of ancient pedogenesis or desiccation, and were deposited subaqueously' (Stahlschmidt et al. 2015: 87).

Of course, there are other ways besides pond storage that bones and lithics can end up commingled in lake bottom sediments. One could kill and butcher the horses directly on the surface of the frozen lake. Any debris left on the ice would obviously end up on the bottom when the ice melted. Or one could conduct all of the butchering and processing activities on shore and simply toss the stones and bones into the lake. And, of course, one can envision a much more complex mix of activities in which some carcasses were processed on shore, others on the ice, after which some parts of the kill were then stored in the pond while others were taken somewhere else. Then, at some point later in the year, hunters returned to the lake and retrieved some of the meat, perhaps processing it further on the ice or on the nearby shore, and concluded by disposing of their trash either on shore or in the lake—in short, a complex palimpsest of inter-related activities.

None of this proves that pre-Neanderthals or Neanderthals were storing meat in the lake at Schoeningen. But I think there is enough evidence, both from the ethnohistoric record and from Schoeningen itself, to suggest that pond storage is a plausible hypothesis, one that should be considered along with others that are currently on the table for discussion (e.g., shore-based butchery with trash disposal in the lake; butchery and trash disposal on the frozen surface of the lake). Needless-to-say, because of the ever-present problem of equifinality and other confounding sources of uncertainty and error, there is no way we can ever 'prove' which of these alternative hypotheses is the correct one. The 'real answer'—the 'truth'—may well be something of which nobody has yet thought. So, rather than steadfastly championing one or another favored explanation, what we need to do instead is to work with multiple competing hypotheses and with equal vigor *attempt to falsify all of them* (Platt 1964). In that spirit, I suggest that pond storage should be added to the list of plausible scenarios as a serious contender.

ARCHAEOLOGICAL IMPLICATIONS AND CONCLUSIONS

As I said at the outset, this is a speculative endeavor. At this point we do not know whether fermented and rotted foods played any role whatsoever in the diets and foodways of Eurasian foragers at any stage during the Paleolithic. We presently lack both the methods and the middle range theory needed to make such practices 'visible' in the distant past. But I hope I have been able to convince my readers that such foods very likely did play a role, perhaps a very important one, and finding out is essential because an answer in the affirmative would mean that a number of our ideas and interpretations of the Paleolithic record may have to be rethought, some quite substantially.

First and foremost, fermenting and rotting meat and fish are low-cost and 'low-tech' means of effectively 'predigesting' protein and fat without having to cook them. This greatly reduces the energetic costs of chewing, digesting, and assimilating them, and—unlike cooking—it can be accomplished 'passively,' that is, when the foragers are engaged in other activities, or for that matter while they are not even present in the area. Cooking, in contrast, requires near constant vigilance, both to keep from overcooking and ruining the meal, and to keep the fire alive and burning at the right temperature.

Moreover, fermentation is ideally suited for preserving and storing fatty meat and fish in climates plagued by incessant rain, overcast skies, fog, or dampness, conditions which can make it exceedingly difficult to dry foods quickly enough to prevent spoilage (autoxidation or rancidity) without having to use up scarce fuel to speed up the process.

The fermentation process also generates important B-vitamins and preserves precious vitamin C that would be degraded or lost if the meat were cooked. In addition to sparing fuel and reducing metabolic costs, preserving vitamin C may be one of the key reasons why fermentation and putrefaction rather than cooking is so important to foragers subsisting on heavily meat- or fish-based diets. So, if Eurasian Neanderthals were in fact 'top predators,' as seems to be the current consensus among Paleolithic archaeologists, they likely faced the same vitamin C constraint as modern northern foragers do, making it very likely that they too had to depend on both raw and fermented or rotted meat.

If fermented and rotted foods did in fact constitute a major part of Neanderthal diet for the reasons just enumerated, that might help to explain the curious on-again, off-again evidence for fire in the European Middle Paleolithic. In fact, variation across time and space in the frequency of hearths, ash deposits, and charred bones, particularly during colder climatic episodes, may help us track the changing emphasis on cooked versus raw and fermented foods in Middle and Late Pleistocene foodways.

It is perhaps important to note in this context that when traditional hunting and gathering peoples in the high arctic actually took the time to cook their meat (and fish), they generally did so, not by roasting, but by very lightly and rapidly blanching or boiling it (e.g., Harry and Frink 2009: 334). One reason for this preference was fuel economy; another, as already noted, preservation of vitamin C (Bender 1979). Hans Saabye and Georg Fries (1818: 254), commenting more than two and a quarter centuries ago on the typical manner of cooking by Greenland Inuit, stated quite emphatically that 'they boil meat and fish an equal time, so that when the former is hardly more than half done, the latter fall to pieces. They do not know how to roast any thing.' A century later Herbert Aldrich (1889:180), commenting upon the way Alaskan Inuit prepared food, put it simply: 'the only way of cooking meat is boiling.' Warburton Pike (1892: 51-52) came to much the same conclusion: 'the general method of cooking everything in the lodge is by boiling, which takes most of the flavour out of the meat, but has the advantage of being easy and economical of firewood.' Ernest Burch (1988: 70) in a much more recent overview of Inuit culinary techniques again emphasized the importance of boiling: 'Eskimos did not dissipate the nutritional potential of their food by overcooking it. Great quantities of meat and fish were eaten raw, usually in either dried or frozen form. When they did cook their food they normally boiled it, usually lightly, and drank the broth.' Finally, Zona Spray (2002: 36) provides helpful insight into what 'lightly' actually means in the context of Inuit boiling:

> "...the term 'boil' might be a misnomer. Not once did I see a bubbling pot. Rather, the liquid gently shimmered at a perfect poaching temperature. With a limited heat source, if a pot did boil, it was only for a short time.... Sometimes only a tiny amount of water was needed to braise or steam. But no matter the exact cooking method, the descriptive term was always 'boiled.'"

Though speculative, it is quite likely that Neanderthals also boiled some of their food, for the same reasons that their ethnohistoric counterparts did, and despite the conspicuous absence of either fire-proof containers or the telltale signs of stone-boiling. One can readily boil water in a perishable hide, paunch, or birch bark container, placing it directly on the hot coals or suspended immediately over the flames, without fear that the vessel will be consumed in the process. Despite their flammable nature when empty, such containers will not ignite, even when heated with a Bunsen burner or blowtorch, so long as they remain filled with liquid (Speth 2015). In fact, direct boiling in this manner is faster, cleaner, and much more fuel efficient than stone-boiling. Thus, if Neanderthals—for reasons of fuel economy and preservation of vitamin C—did prepare some portion of their meat by light, rapid boiling rather than by roasting, such behavior might well contribute to a number of 'troublesome' taphonomic problems for the Paleolithic archaeologist. For example, judging from the ethnohistoric literature many of the hearths used for this kind of cooking are likely to have been small and very ephemeral, the fuel at times simply gleaned from locally available herbaceous vegetation and even mosses, and the incidence of burning on bones, flint chips, and other objects minimal or non-existent. In short, if Paleolithic foragers prepared meat by rapidly boiling it, the result would be a further amplification of the 'on again, off again' nature of the evidence for Middle Paleolithic fire use.

Deliberately fermenting or rotting meat and fish also provides a safe and effective 'low-tech' way to store foods over periods of months, even during the warmer summer months. By simply placing fermenting and rotting animal foods in a shallow pit, or under a pile of rocks, or in a bog, or on the bottom of a pond, foragers can create valuable food caches at strategic points on the landscape. Judging from the literature, these cache points are often either just outside the camp or settlement, along major routes, or close to where a given resource is procured (e.g., fishing spots, caribou/reindeer intercept points, etc.). Thus, the obvious scarcity of pits directly within Middle Paleolithic sites would not rule out the possibility that Neanderthals nonetheless routinely cached meat in pits, since such features are not likely to be located where most of our excavations tend to be focused. In any case, if Middle and Upper Paleolithic foragers were routinely rotting meat and fish in caches, regardless of whether these caches were in pits, bogs, or ponds, it would be misleading to characterize their cultural systems as ones that lacked storage. Quite the contrary, such dispersed forms of food caching may well have been a vital part of their adaptations, and a key factor in their decisions about when and where to move and the route they should take in order to get to their final destination while minimizing the specter of starvation en route. We just have not figured out ways to 'see' these caches yet.

As I became increasingly aware of the likely importance of fermented and rotted foods in the diets of northern peoples, I began to wonder whether such practices might have an impact on the results of stable isotope analyses, particularly $\partial^{15}N$ values. When foragers consume meat or fish that has been rotted for weeks or months, they are not just eating protein, they are eating millions upon millions of bacteria, both anaerobic and aerobic, plus a complex 'soup' composed of endogenous and exogenous enzymes and metabolites generated during the progressive decomposition of the food.

Of all the complex by-products and end-products of putrefaction, perhaps the ones of most relevance to stable isotope studies are the volatile compounds that are generated along the way, and particularly three nitrogenous gases—ammonia, cadaverine, and putrescine (Abdel-Aziz et al. 2016; Buňková et al. 2016; Carter and Tibbett 2008: 31; Cobaugh 2013; Donaldson and Lamont 2013; Janaway et al. 2009: 316, 318; Komitopoulou 2012; Metcalf et al. 2016: 161; Min et al. 2007; Paczkowski and Schütz 2011; Pessione and Cirrincione 2016; Ruiz-Capillas and Jiménez-Colmenero 2004; Sander et al. 1996; Thorn and Greenman 2012: 3). These volatiles, which result from the breakdown of proteins and amino acids, are important contributors to the characteristic bloating and foul smell that typically accompanies the decay of animal matter (Dent et al. 2004).

The extent to which these gases are formed depends on a host of factors, among which are: the amount of time that has elapsed since death (the postmortem interval or PMI); available moisture; ambient temperature; whether the carcass was buried, left on the surface, or immersed in water; the properties of the surrounding soil; characteristics of the animal itself, including species, body size, health at the time of death, how much body fat was present, whether or not the animal was gutted, dismembered, and skinned before putrefaction; and how often the meat cache was accessed by the hunters over the course of its use-life. Given this array of potentially confounding factors, it is very hard, without a great deal of baseline experimental work, to predict the quantity of nitrogenous gases that would have been generated and subsequently lost to the surrounding air, water, or soil. But this issue is interesting and potentially important because the production of these volatiles, especially ammonia, may have left the putrefied food cache enriched in ^{15}N (I am grateful to Margaret Schoeninger for pointing out this likely source of enrichment, personal communication, April 2017).

There seem to be very few studies that have explicitly looked at the impact of putrefaction on stable isotope values, and the ones that I have come across deal solely with aquatic resources and experimental designs that are not necessarily ideal analogs for deliberate human meat caching. Nevertheless, their results do show that putrefaction of meat over sufficient lengths of time and under appropriate ambient temperature conditions can elevate ^{15}N values quite substantially (see, for example, Wheeler et al. 2014: 116 for an example involving salmonid fish decomposing in a terrestrial setting; see also Burrows et al. 2014 and Yurkowski et al. 2017). Whether the extent of such enrichment would have been sufficient to elevate ^{15}N values to levels comparable to what we see in European Neanderthals (Bocherens 2011; Wißing et al. 2016) is, of course, unknown, but it would seem to be a possibility well worth looking at more closely.

There are other components of traditional arctic diet that might also lead to ^{15}N enrichment. Eating the larvae of warble flies found beneath the skin of caribou and reindeer, a widespread practice among northern foragers, might be one such mechanism, as would consuming the maggots that almost invariably infested their putrefied meat and fish (Anderson and Nilssen 1996; Bennett and Hobson 2009; Hocking et al. 2009; Nilssen 1997; I am grateful to Melanie Beasley for drawing my attention to this possibility, personal communication, March 2017). As far as the maggots are concerned, the degree of enrichment would again depend on many factors, including whether the rotted food was terrestrial or aquatic in origin, marine or freshwater, the degree to which the food was putrefied, and, of course, on how substantial a contribution the maggots made to the overall diet of the foragers.

Turning now to taphonomy, if Paleolithic peoples made regular use of fermented and rotted foods, this would almost certainly add to the complexity of our assessments. For example, by reducing the extent to which Paleolithic foragers relied on any sort of cooking, the incidence of burning will almost certainly be affected, as will the presence of hearths, ash lenses, scattered charcoal, and thermally 'popped' or potlidded flints. Likewise, since fermentation and rotting greatly soften meat by breaking down the component proteins, one can often simply pull chunks of meat from the bones with little or no need for a knife. This should lead to a significant reduction in filleting marks. Joints also become easier to separate and can often be pulled apart with little or no cutting. Could these consequences of putrefaction perhaps also blur some of the cutmark criteria we use to distinguish early carcass access and hunting from later access and scavenging?

Interestingly, modern arctic foragers sometimes freeze the rotted product before they eat it. This seems to be particularly common with rotted fish heads and caribou or reindeer stomach contents. Freezing of course makes the meat more difficult to remove from the bones and may well lead to a more haphazard pattern of cutmarks, much like that seen on some of the human bones from the famous 19th-century Alferd [sic] Packer wintertime cannibalism case in the North American Rockies (Rautman and Fenton 2005), and from Middle Pleistocene Schoeningen (Starkovich and Conard 2015), although it would probably not explain the haphazard pattern seen by Stiner et al. (2009) at Qesem Cave in Israel.

Rotted fish heads were often frozen before being eaten and then allowed to thaw just enough so that they took on the texture of a firm ice cream cone (Stefansson 1960: 36). They were then eaten, bones and all. Since the spine of the fish was often removed and discarded at or near where the fish was caught, not at camp, the only direct evidence at a residential site that fish were part of the diet—the heads—were first reduced to the consistency of mush by fermentation and then eaten in their entirety, leaving virtually no evidence behind for the archaeologist to find. It is worth noting in this context that rotted fish heads (stinkfish, stinkhead, or stinky head) were, hands-down, among the all-time favorite foods of peoples across the entire North American arctic, so fish consumption in analogous environments during the Paleolithic may indeed be difficult to detect!

Continuing with the taphonomic theme, how attractive are bones of fermented and rotted animals—with or without marrow—to carnivores like hyenas? And how long does that attraction persist? What consequences might fermentation have on the number and location of carnivore gnaw marks, punctures, and other sorts of damage?

Finally, ungulate bones are often thought to have been used as fuel during the Eurasian Middle and Upper Paleolithic. Are the combustion properties of fermented and unfermented bones comparable, or does fermentation alter a bone's utility as a fuel? What effect might fermentation have on the value of an epiphysis for subsequent grease-rendering?

One could go on enumerating other ways in which reliance on fermented and rotted meat and fish might impact the way we interpret the Paleolithic record. I hope what I have presented here is at least sufficient to show that these types of foods may have been of great importance to foragers in the past. Deliberate fermentation and putrefaction were not just last resort strategies to stave off starvation when all other means failed, nor were they a mere culinary curiosity. Instead, fermenting and rotting meat and fish may well have been vital to the survival and success of Paleolithic 'top predators' as they penetrated the colder climes of Pleistocene Eurasia. We now need to pool our collective efforts, expertise, and imagination in order to find ways to evaluate these speculations and, in the process, move toward a more complete and realistic understanding of the lifeways and adaptations of these stone age pioneers of the colder climes.

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