Inuit Foodways

Overview of the Inuit

North America was one of the last continents that humans inhabited, because during the Wisconsin glaciation of 50,000-17,000 years ago, falling sea levels allowed people from Siberia to migrate across the Bering land bridge (Beringia) joining Siberia and Alaska. Rising sea levels after the Last Glacial Maximum resulted in the submersion of the Beringian land bridge, with the final re-submergence occurring around 11,000 years ago. Following migration to Alaska, people were blocked from inland migration due to the Laurentide ice sheet covering most of Canada. Expansion into Canada occurred at least 15,000 years ago, though it may have been earlier. The Clovis peoples were considered the first widespread Paleo-Indian inhabitants of North America, with early sites dating to 13,500 years ago. They are considered ancestors to all indigenous peoples in the Americas.

The Paleo-Indian (also known as Paleo-arctic) tradition is poorly defined by archaeologists; though some data suggest that the Paleo-Indian relied on a terrestrial adaptation to living in the Arctic. However, this conclusion could be due to rising sea levels submerging

coastal sites occupied by the Paleo-Indians (Park, 2017c). The Arctic Small Tool tradition, dating between 4500 and 2800 BP, does not seem to be related to the preceding Paleo-Arctic tradition; however, the Arctic small tool tradition likely developed into the Norton tradition in Alaska and the Dorset culture in Arctic Canada (Park, 2017a).

The Norton tradition was a culture that developed in the Western Arctic along Alaska's shore of the Bering Strait. It lasted from 1000 BC through 800 AD. The Thule tradition developed from Norton inhabitants of St. Lawrence and Bering Strait Islands around 700 BC. The Thule tradition represented a new type of adaptation to the Arctic environment. Thule innovations included hunting large sea mammals in open water using drag floats attached to the harpoon line and the use of large skin boats and dogs to pull large sleds (Park, 2017d). The Thule developed in coastal Alaska by AD 1000 and split from a related Aleut group approximately 4,000 years ago and from northeastern Siberian migrants. The Thule tradition lasted from approximately 200 BC to 1600 AD. The Thule expanded eastwards across Canada and reached Greenland by the 13th century, totally replacing the Dorset culture by the 15th century. Following the disruptive effects of the "Little Ice Age" (1650-1850) and intensified contact with Europeans in the 18th century, the Thule communities broke apart and the people became

known as the Eskimo, and later, the Inuit." (Wikipedia, The Free Encyclopedia. "Thule People.").

As mentioned above, the Inuit are descended from the Thule culture. "The Inuit are Indigenous People whose territory lies within the circumpolar Arctic, including Canada, Alaska, Greenland, Scandinavia and Russia" (Fediuk, Hidiroglou, Madère, & Kuhnlein, 2002). The Inuit are distinct from other aboriginal populations of the Americas, such as Indians (Native Americans), and their way of life contrasted sharply with other aboriginal populations south of the tree line. The Arctic environment inhabited by the Inuit necessitated greater reliance on terrestrial and marine animal resources instead of plant-based resources. Distinctive adaptations of the Inuit include snowhouses, large and small watercraft, drag floats, toggling harpoons, and dog traction (Park, 2017b).

Recent census data suggest that there are approximately 135,000 total Inuit living in Canada, Greenland, Denmark, and the United States.

Side note: "The Dorset culture (also called the Dorset Tradition) was a Paleo-Eskimo culture (500 BCE–1500 CE) that preceded the Inuit culture in Arctic North America." (Wikipedia, The Free Encyclopedia. "Dorset Culture."); though the Inuit were not descended from the Dorset.

General societal structure. Inuit communities have no leadership positions or hierarchy. The organization of the community was primarily based on familial relationships, with families joining together via marriages. Economic relationships were also organized in relationship to family lines. Except in Alaska, the largest Inuit communities consisted of approximately 50 people and communities only consolidated when food resources were abundant, otherwise spreading out when resources were scare (Stern & Stevenson, 2006)(p.55-56). The Inuit of central Canada often spent winters in temporary snowhouse communities on the sea ice (which allowed them to hunt seals at breathing holes), sprints on the coast, and summers inland hunting caribou (Park, 2017b). Alaskan Inuit communities (Inupiat) were able to establish permanent communities due to living in a biologically rich environment. Thus, their communities had as many 500 people from several extended families (Stern & Stevenson, 2006)(p.56). The Alaskan Inuit lived in semi-subterranean houses, not snowhouses (Park, 2017b). Despite the ability to establish permanent communities, the Inupiat did not live in villages year-round. Rather, individual family-groups lived in seasonal camps for a large portion of the year (Stern & Stevenson, 2006)(p.56).

The traditional Inuit diet

The Inuit's ancestors, the Thule, relied on bowhead whale for survival, as they provided meat for food, blubber for oil, and bones for building structures and making tools. The Thule outside of whaling communities survived predominantly on fish, large sea mammals, and caribou. (Wikipedia, The Free Encyclopedia. "Thule People.").

The Inuit diet is largely carnivorous, relying primarily on high-fat, high-protein foods, such as sea and land mammals, fish and fowl, with edible Arctic plants supplementing the diet. This combination of food sources provides a balanced, nutritious diet with vitamins, minerals, proteins, and unsaturated fats (Spray, Winter 2002)(p.32).

The Inuit food system emphasizes sea mammals, such as walrus, seal, and whale. Ringed and bearded seals are the most important aspect of the Inuit diet, comprising the largest part of their diet. Archaeological data from early Paleoeskimo sites in Arctic Canada suggest ringed seals were an important part of the diet as early as c. 4000-3500 BP (Murray, 2005). The Inuit typically eat ringed seal meat in frozen/raw or cooked form; whereas, bearded seal meat is usually cooked. A typical day of Inuit diet would include large quantities of sea mammals, with seal oil

being used to flavor both meats and plant-products. Smaller quantities of plant-based foods might be consumed, though the prevalence of plant-based foods in the diet would vary based on the time of year, with greater consumption occurring late Spring through early Autumn.

Seal. The emphasis on seals as a food source in the Inuit diet cannot be underestimated, with the Inuit referring to seal as *auqsiut* - "rejuvenator of human blood" (Borre, 1991). Seal blubber, meat, and blood are considered essential to the health of the Inuit. The Inuit believe seal blood is necessary for replacing depleted nutrients and rejuvenating the blood supply ("Seal blood gives us our blood. Seal is life-giving.") and that combining seal and human blood "creates a healthy human body and soul" (Borre, 1991). Seal meat and blubber are considered necessary for the Inuit to stay strong: "When we haven't eaten fresh meat for a while, we get really tired. And then, when we do eat it, our body gets satisfied because we are Inuit."—Anonymous Inuk, Sanikiluaq, reported in Usher et al. 1995 (Freeman, 1998) (p.45). Seal meat is also considered medicinal for those who do not have regular access to it, with sickness often attributed to a lack of seal meat. However, hunters and young men do not need or use seal meat as medicine because they regularly consume seal to maintain their strength to hunt (Borre, 1991).

Whale. In addition to seal, whale is also considered essential to the Inuit diet. The primary sources of whale meat in the Inuit diet are Beluga and bowhead whales [1]. The Inuit preferentially hunt juvenile whales, as they are safer to hunt and have more flavorful skin [1]. The beluga were used for food, as well as for oil, skin, and blubber (Freeman, 1998)(pp.59-61). The Inuit believe in the health-promoting properties of whale oil, blubber, and fresh meat.

Other sea mammals consumed include walrus, narwhal, and harp seals (Fediuk et al., 2002; Kuhnlein, Chan, Leggee, & Barthet, 2002). The kauk (skin) and stomach contents of the walrus may also be eaten (Fediuk et al., 2002). Along with sea mammals, other sources of fat and protein in the Inuit diet include land mammals (i.e. caribou, polar bears, muskox, and rabbits), birds (i.e. ducks, grouse, and ptarmigan) and their eggs, and fish and shellfish (i.e. arctic char, sculpin, trout, salmon, etc.) (Fediuk et al., 2002; Kuhnlein et al., 2002).

Dovekie. The dovekie are a particularly important bird in the Inuit diet. Historically, the dovekie (a.k.a. “little auk”), a small Arctic bird, played an important role in the Inughuit (Polar Eskimo) and Thule subsistence, in part due to large colonies of dovekie residing in northwest Greenland (Johansen, 2013)(pp.75-76). Though the meat of a single dovekie provided meager sustenance, as many

as ten dovekie are easily caught in one netting event and the meat of twelve dovekie is equal to approximately one pound of meat (Johansen, 2013).

Plant foods. Plants played a lesser dietary role in Inuit's diets due to the fact that native Arctic plants could not be cultivated for food (Fediuk et al., 2002). Despite the lack of cultivation, the Inuit still gathered seasonal plant foods for consumption, including berries, grasses, tubers, roots, and seaweed, among others (Kuhnlein, Kubow, & Soueida, 1991)(p.228).

Greens. The greens Inuit consume include wild cucumber (*Saxifraga punctate L.*), roseroot (*Sedum roseum L.*) (Turner, 1981)(p.2341-2342), alpine knotweed (aka Wild Rhubarb- *Polygonum phytolaccaefolium*) (Porsild, 1953), sourdock (*Rumex arcticus*) (Spray, Winter 2002)(p.34)(Kuhnlein, 1991)(p.220), diamond-leaved willow (*Salix phylicifolia*) (Kuhnlein, 1991)(p.261), fireweed and dwarf fireweed (*Epibolium angustifolium* and *latifolium*, respectively) (Kuhnlein, 1991)(pp.217-218), mountain sorrel (*Oxyria digyna*) (Porsild, 1953)(p.25), and spoonwort/scurvy-grass (*Cochlearia officinalis L.*) (Turner, 1981)(p.2336).

Berries. Berries are another common plant food consumed by Inuit, with crowberries (*Empetrum nigrum L.*) being the most important fruit in the Arctic (Porsild,

1953)(Porsild 1953). Other common berries consumed include the bearberry (*Arctostaphylos uva-ursi*), mountain cranberry (*Vaccinium vitis-idaea*) (Kuhnlein, 1991)(pp.165-186), baked-apple berry (*Rubus chamaemorus L.*) (Porsild, 1953)(p.21), and bog blueberry (*Vaccinium uliginosum L.*) (Turner, 1981)(p.2343).

Seaweeds, Lichens, & Mushrooms. "On the Arctic coast seaweeds were important as a general famine food" with Inuit collecting seaweed and storing it as a fall back food source, though this was more common among the Inuit of Baffin Island and Labrador (Kuhnlein, 1991)(p.28). The Inuit had a "general antipathy for mushrooms", rarely eating mushrooms, which were known locally as "that which causes your hands to come off". This was despite the fact that almost all mushrooms on the tundra, except *Amanita rubescens,* were edible (Kuhnlein, 1991)(p.39).

Root and Tubers. Common roots and tubers consumed by the Inuit include the "Eskimo potato"/licorice root (*Hedysarum alpinum*), black saranna, mouse nut (*Eriophorum angustifolium Honckeny*), meadow horsetail (Equisetum pretense), wooly lousewort (*Pedicularis lanata*), Alpine bistort (*P. viviparum*), and spring beauty (*Claytonia caroliniana*) (Kuhnlein, 1991)(p.229).

Grains. Inuit began eating grains following contact with Europeans as a result of commercial fur trade and the whaling industry. One traditional grain product was paluraq, a type of bannock (Searles, 2016)(p.31).

Intelligence and Sensing used for finding food

The ability to locate seal lairs required a substantial amount of critical thinking, the use of visual and auditory senses, and training so that the Inuit could recognize the lairs (more details under Capture section). For instance, they passed down knowledge indicating that the presence of fox urine or feces on a drift likely indicates the presence of a lair. Also, hunters used their sensory abilities, including vision and hearing, to find food. For example, the use of visual cues, such as changes in sunlight reflecting off of a drift, and auditory cues, such as listening to the sound made while walking over a lair, require substantial intelligence and training by others to understand how these signs are indicative of the presence of a seal lair (Furgal, Innes, & Kovacs, 2002). The Inuit also trained dogs to sniff out seal lairs. Finally, the method by which mother seals were captured (as described under hunting techniques) required substantial problem-solving skills and an understanding of seal behavior to develop and successfully execute the techniques (Furgal et al., 2002).

The technique the Inuit used to kill a whale without scaring it away also required substantial intelligence, as the Inuit learned that repeatedly lancing the whale in the kidney region would cause the whale to bleed out without it ever fleeing from the hunters. New hunters were trained by experienced hunters to recognize the correct place to strike without scaring the whale (Freeman, 1998)(pp.77-78).

Intelligence played a particularly important role in the Inuit successfully gather food from rodent caches. Doing so required substantial traditional knowledge, experience, training, good timing, skills in using appropriate tools, avoidance of boars and bears, and the ability to recognize toxic plants (Stahlberg & Svanberg, 2010). Additionally, the Inuit successfully trained domestic dogs to find rodent caches. Interestingly, the Inuit would often replace roots plundered from rodent caches with fish, in order to help the rodents survive, as they believed that, since the Inuit could survive on fish, rodents could as well (Stahlberg & Svanberg, 2010).

The Inuit used stars to navigate on the sea and manmade stone landmarks known as inuksuk to navigate on land whenever there were insufficient natural landmarks. The inuksuk were often build to identify specific fishing sites and hunting grounds, to mark caches of food, and to assist

in herding caribou into contained areas for slaughter (Saleeby, 2005).

Working Together/Cooperation. Cooperation was a particularly important component of whale hunting, as the men kayaking had to work together to drive schools of beluga ashore to be killed (Freeman, 1998)(p.62). The Inuit also had to work together during summer months when they were rushing to preserve food for the months ahead and men and women are dependent upon one another to finish all of the tasks required to help them survive the winter (Stopp, 2009).

Locomotion

The primary forms of transportation for the Inuit were boats, dog sleds, or walking on foot. The Inuit used two different types of boats. The qajaq (now referred to as a kayak) was a single-passenger boat with a watertight, seal-skin cover. The qajaq varied in length from (3—9 meters) (10—30 feet) and were incredibly narrow (38—82 cm) (1—3 feet). Qajaq's were propelled with double-bladed paddles. The qajaq's were buoyant and easy to right, including the ability to be flipped upright if overturned (Canadian Museum of History, 2017b). These characteristics of the qajaq made it an ideal form of locomotion on the water, particularly when the Inuit were

hunting beluga whale, as they could easily and silently maneuver within close proximity of the whale without causing a disturbance, as the whales were not afraid of the kayaks (Freeman, 1998)(p.78). Hunters often attached a blade to the end of their kayak paddles to use when hunting whales (Freeman, 1998)(p.77). Also, the length of the qajaq allowed hunters to fasten their weapons, such as the harpoon and lance, to the top of the qajaq. The light weight of the qajaq also saved the Inuit time because they could easily carry a qajaq overland (Canadian Museum of History, 2017b).

The qajaq was preferable to the umiaq for hunting due to its maneuverability: "The kayak is silent, moves quickly, and is much better to handle than any umiaq"—Jim Kilabuk, Pangnirtung, 1985 (Freeman, 1998). The umiaq was originally developed during the time of the Thule. It was a large open boat constructed of a wooden or whalebone frame covered in animal skins that were waterproofed with seal oil. The umiaq were 6—12 meters (20-39 feet) long and 1.5—2 meters (4 ft 11 in—6 ft 7 in) wide and weighs approximately 68 kg (150 lbs). The umiaq had a flat bottom which allowed the boats to come close to shore without becoming beached. The umiaq was typically propelled by oars (if women were paddling) or paddles (men); however, sails were occasionally used. Although poorly suited for hunting, the umiaq was useful for transporting people, dogs, and goods during the

summer. The umiaq could hold up to 30 passengers (Canadian Museum of History, 2017c). Typically, the umiaq was used for specifically transporting women and children during the summer, whereas men travelled by qajaq, hence the umiaq also being known as a "woman's boat" (Canadian Museum of History, 2017a).

The Inuit used dogsleds (qamutik) for transportation across land and sea ice during the winter. Sleds were constructed of wood, animal bones, or the baleen from a whale's mouth that were lashed together with rope made from bearded seal (Hamilton, 2008). Dogs worked in teams, either side-by-side or in a fan formation to pull the sled. Dogsleds weren't typically used for hunting; however, they were involved in food gathering, as they were used to transport the Inuit to retrieve their underground caches of greens and berries during the winter (Spray, Winter 2002)(p.34).

Territory

Historically, the Inuit did not have defined territories; however, modern day territories differ. In Canada, the Nunavut Land Claim Agreement of 1993 gave the Inuit a separate territory called Nunavut, which was the largest Aboriginal land claim settlement in Canadian history. The agreement gave the Inuit approximately 350,000 km^2

(140,000 miles^2) of land (Minister of Public Works and Government Services Canada, 1997).

While there are no specific Inuit territories in Greenland, approximately 88% of Greenlanders identify as Inuit (Central Intelligence Agency, 2016). In Alaska, the passage of the Alaska Native Claims Settlement Act (ANCSA) in 1971 settled land and financial claims for the Alaskan Natives and resulted in the distribution of one-ninth of Alaska's state lands plus $962.5 million to over 200 local Alaska Native corporations (Linxwiler, 2007).

Due to their traditional lack of defined territories, the Inuit rarely waged war or fought to protect territory. War and conflict were in part rare due to the Inuit values of self-restraint and sharing (nigiqtuq) and due the fact that Inuit depended on each other for survival (Canada's First Peoples, 2017). Despite their generally peaceful existence, there is evidence of warfare between the Lowland Cree and the Inuit of Subarctic Canada in the Hudson Bay area. This warfare occurred prior to European expansion and it is hypothesized that the warfare was a result of changing climate conditions and a search for resources. Inuit aggression largely ceased by the 1680s, though the Cree continued raids to the north until 1793. Increases in employment and greater financial stability, combined with Inuit access to guns, ended Cree violence (Bishop & Lytwyn, 2007).

Capture

Hunting methods and techniques

Seals. The Inuit locate seal structures using a variety of techniques. Seal structures are often located when: 1) hunters perceive a sag or depression in a snowdrift; 2) there is greater sunlight reflection off a drift than elsewhere; 3) a drift has been marked (with urine or feces) or previously entered by a bear or fox; or 4) the roof of the seal lair has melted through (Furgal et al., 2002). The most common method for locating a seal lair is the presence of a depression in the surface of the snow due to the heat in the lair from the seal's body heat causing the snow covering the structure to melt (Furgal et al., 2002). Occasionally, hunters find breathing holes and lairs by probing drifts with a harpoon, though must lairs are located by sight (Furgal et al., 2002). Once hunters find a lair, they break the snow covering the structure by jumping on the drifts. Hunters then look inside the lair to search for a seal pup, if present, the seal pup is removed. If not present, the hunter waits for the pup to move to the main chamber to get into the water and then captures the pup. The pup is then used as bait for the mother seal. The hunter ties a rope to the pup's hind flipper and lowers it into the water, allowing the pup to swim near the breathing hole. When the hunter feels a strength pull on

the rope, the pup is slowly pulled to the surface. The mother holds the pup in her mouth or fore flippers, so, pulling the rope causes the mother-pup pair to pass below the breathing hole, at which point, the mother is harpooned (Furgal et al., 2002).

Beluga and bowhead whales. Archeological data suggests ancestors of the Alaskan Inuit hunted beluga whale as early as 5,500 years ago (Freeman, 1998)(pp.59-61), and indicate that the Arctic Inuit have hunted whales in northern Canada for at least 2,000 years (Freeman, 1998)(p.74). "Inuit hunters typically use one of four methods for catching beluga: shooting and harpooning from the ice edge in spring, shooting in open water from boats, netting them, or driving the animals into shallow water" (Freeman, 1998)(p.61). Beluga whales are hunted in the early part of the summer. The Inuit often hunt beluga in kayaks. Hunters work in groups, approaching the whale from the rear and to one side, they pursue and tire the whale so that it remains on the surface and then harpoon the whale several times. Hunters may also work in sequence, one hunter following the next, with each individual hunter lancing the whale in the kidney region with a blade attached to the end of the kayak paddle until the whale dies through loss of blood without attempting to escape (Freeman, 1998)(p.77). Another group approach to hunting involved beluga drives, in which hunters, guided by a shaman, drove the beluga into shallow water and

then picked off individual beluga with harpoons before tying them to the kayak and pulling them to shore (Freeman, 1998)(p.61). When netting beluga, the hunter uses immense nets made of hides or sealskin line, which are set near rocky islets or reefs. The whales enter the nets, are entangled, and they are held under the water by heavy anchor stones attached to the net, causing them to drown (Morseth, 1997)(p.247). Bowhead whales were hunted in groups, with several boats approaching the whale and harpoons being used to tire the whale before it was killed with a long lance tipped with stone or bone (Freeman, 1998)(p.71).

When hunting whales, the Inuit rode in kayaks and typically used lances (kappun) or toggling harpoons, depending on water depth. If hunting in deep water, the Inuit might use a rifle or a small spear called a ningiqpak, which was tossed with a throwing board. They also had a long spear called a qavluniin that embedded a toggling harpoon point into the animal (Morseth, 1997)(p.245). The Inuit also used beluga nets made out of seal skin lines and smaller nets, made of hide, for smaller whales and porpoises (Morseth, 1997)(p.247).

Dovekies. The Inuit use a net attached to the end of a pole to catch dovekies (Johansen, 2013)(p.79). The nets consist of light strings of sealskin knit together and the poles are

made from narwhal tusk or dry willow branches (Johansen, 2013)(p.79). The hunters hide in hollows between boulders or behind a small, man-made wall to capture the birds. Seven to ten birds are typically captured at one time and the birds are killed by pressing the breastbone to stop the heart beating or by the hunter crushing the head between their teeth (Johansen, 2013)(p.80).

Plant Gathering Techniques

Greens. The Inuit gather greens when available, often stopping in one location for several days to gather greens and process extra greens for storage in order to not waste any of the food (Spray, Winter 2002)(p.34) and gathering enough to meet the family's long-term needs (Griffin, 2001). "Not knowing what the future holds, Eskimos learned to take what is offered, when it is offered" (Spray, Winter 2002)(p.34). The Inuit pick the leaves of stalks of pre-flowering sourdock plants in early July, as that's when the leaves are the largest and taste the best (Kuhnlein, 1991)(p.220). In contrast to sourdock, the shoots, buds, and leaves of diamond-leaved willow are collected in early spring because older, larger leaves are too strong tasting (Kuhnlein, 1991)(p.261).

Berries. While the Inuit gathered a variety of berries, crowberries were particularly important because, while

the berries ripen in August, they remain on the plants through the winter and can be gathered even from under snow (Kuhnlein, 1991). Crowberries are abundant in arctic regions, making them the most important despite having a poorer flavor than other berries (Porsild, 1953)(p.21). Bearberries were picked after the first frost (Kuhnlein, 1991)(pp.165-166). Women designed a berry-picking basket that had straight twigs that were six inches long and half an inch apart projecting from one side of the basket. This allowed them to swipe the basket through low berry bushes, quickly filling the basket and avoiding exposure to the snow when finding berries hidden under the snow (Spray, Winter 2002)(p.34).

Seaweeds, Lichens, & Mushrooms. The Inuit on the Arctic cost, particularly those of Baffin Island and Labrador, collect kelp in the summer and winter (Kuhnlein, 1991)(pp.27-28). Reindeer lichen was primarily 'harvested' from the partially digested stomach contents of caribou and other ungulates but was also gathered from rocks (Kuhnlein, 1991)(pp.37-38). Due to their dislike of mushrooms, the Inuit did not gather them for consumption (Kuhnlein, 1991)(p.39).

Roots and Tubers. The Inuit gathered plant foods from rodent stores, particularly roots and tubers. Common roots and tubers taken from rodent stores include the "Eskimo

potato”/licorice root (*Hedysarum alpinum*), black saranna, mouse nut (*Eriophorum angustifolium Honckeny*), meadow horsetail (Equisetum pretense), wooly lousewort (*Pedicularis lanata*), Alpine bistort (*P. viviparum*), and spring beauty (*Claytonia caroliniana*) (Kuhnlein, 1991)(p.229). The Eskimos of Alaska had specially trained dogs for located rodent caches. The used these dogs to gather liquroice-root in particular, as it was a favored vegetable and they wanted to avoid competition with black and brown bears. Liquorice-root matures in August but the Inuit could gather them until the ground froze. However, they tasted better in the spring, prior to new growth starting, and became tough and woody towards autumn (Porsild, 1953)(p.31). Woolly lousewort were picked in June (Kuhnlein, 1991)(p.263). Mousenut stem bases were collected in early summer, with corms dug in early spring or fall if they weren’t gathered from rodent caches (Kuhnlein, 1991)(pp.75-76). Eskimo women carved digging trowels and picks from local jade and flint and use these to rob roots from mouse nests or uproot willow stems (Spray, Winter 2002)(p.33).

Grains. Although the Inuit ate grains, they were not available locally and thus were not harvested. Rather, grains were attained via trade with Europeans (Searles, 2016)(p.31).

Food Storage and Preservation

General. Women and children spent significant amounts of time on food preservation during the summer, taking advantage of the abundance of food in the summer and rushing to preserve all possible edible food for the coming winter (Spray, Winter 2002)(pp.32-33). Due to the ready availability of sun and wind, drying food was the Arctic Eskimos' most common method for preparing and preserving food (Spray, Winter 2002)(p.34). When drying foods, such as fish, no salt was added, which is contrary to common food drying methods, because there was no salt available (Spray, Winter 2002)(p.36). Preventing flies from laying eggs in drying fish was a particular concern and, in central regions, slow-burning embers were used to smoke flies away; whereas, in coastal regions, people relied on breezes to keep the flies away and prevent maggots (Spray, Winter 2002)(p.36).

Food was preserved in cold cellars dug into the permafrost to store pokes (storage vessels made from sealskins or animal parts), baskets, and fish for the winter. "Cold cellars were historically dug into the permafrost, or icy ground, to keep food-filled pokes and baskets cold during the summer and frozen during the winter. Some of the old cellars, laboriously carved into the frozen earth with walls as straight and smooth as any modern house, were six feet deep and six feet square. There were also

huge cellars with circular walls, lined with burlap bags and grasses to hold tons of fish for the winter." The storage baskets constructed by women were made of birch, were waterproof, and were constructed to nest on top of one another so only the top basket required a cover (Spray, Winter 2002)(p.34).

Prior to the advent of 55-gallen drums, the Inuit made storage containers out of the hide of belugas or sealskins. To make a bag from the stomach of a whale, the women removed the outer muscle membrane and inner lining to create a balloon-like bag, which was then filled with berries (Morseth, 1997)(p.250). When using a sealskin to make a poke, the skin was sewn into a waterproof container and turned fur-side-in. This was then stuffed with meats, plants, and seal oil and stored in a cold cellar over the winter months. Occasionally, caribou or moose stomachs or duck skins were used as storage containers (Spray, Winter 2002)(p.35).

Animals

Whale. Beluga whale spoils quickly when left in the sun, so the meat was processed very quickly. Often, the meat was dried, preserved in oil and stored in sealskin containers, or fermented and then stored for winter food. The primary food stored for winter was maktak, oil, and

black meat. The head and tail were stored in pits dug out of the permafrost and covered with logs (Freeman, 1998)(p.62). The entire whale was used for food, oil, storage containers, skin ropes, and dog food (Morseth, 1997)(p.249). The parts of the beluga that could not amenable for long-term winter storage were used as summer food.

Walrus. As mentioned above, Igunaq is a common method of preparing walrus meat and is also a form of food preservation (Wikipedia, "Igunaq"). However, there are risks associated with this food preservation technique and improper production can lead to botulism, which can result in illness or death (Wikipedia, "Igunaq").

Fish and fish eggs. Fish eggs not consumed as part of Eskimo ice cream were layered with fish heads and fermented for later consumption (Spray, Winter 2002)(p.36). Fish were gutted and hung on horizontal bars to dry (Spray, Winter 2002)(p.34).

Fermenting fish without the use of salt for food preservation likely began over 9200 years ago. The combination of the large amount of time required for smoking and drying foods for preservation and short fishing seasons with large catches likely led to the use of fermentation for fish preservation in arctic areas. The arctic weather may also have influenced the decision to

use fermentation as a food preservation technique, as it was often too damp to dry fish and meat (Boethius, 2016). Ethnographic accounts of fish fermentation in the arctic suggest that the most common practice is to bury the fish in a hole dug through the top soil and into the underlying clay. These holes are typically near water sources to minimize the transportation distance from where the fish were caught to their storage site (Stopp, 2009). Traditional fermentation included the use of 'back-slopping' in which a small amount of previously fermented food was added to the next fermentation batch to speed up the fermentation process and introduce *Lactobacilli* to the food. A bark layer often covered the hole, which was important as bark acid helps the fermentation process, acting like a starter to speed up fermentation and improve the quality of the end product (Boethius, 2016). Since fish were fermented without salt, it was extremely important to maintain a constantly cool environment to prevent botulism bacteria from forming, and the Inuit stopped the fermentation process by letting the fish freeze to prevent both spoilage and making the fish taste too strong (Boethius, 2016).

Caribou. Caribou captured during the autumn hunt were cut into thin strips and spread out to dry. Once dried, the meat strips were cached with stones piled on top to preserve the meat (Stefansson, 1913)(pp.358-359). Dried meat was either mixed with fat or stored dry. Bone

marrow was also stored for later consumption (Stopp, 2009).

Dovekie. The Inughuit often stored dovekie under stone heaps to freeze or stuffed them inside seal-skin bags to make kiviaq (Johansen, 2013).

Plants

Greens. Extra greens are preserved for later consumption by boiling, fermenting, or souring them with blubber (Kuhnlein, 1991). Another common preservation method is to cook greens, drain the juice, and then roll the greens into a ball large enough for dinner or a snack. These balls were then placed in an underground cache covered with grass and rocks (Griffin, 2001). The people would return to seasonal caches in the fall and transport the stored food to their winter village (Griffin, 2001).

Berries. The Inuit fermented berries. They slowed down the fermentation process by spreading wilted acidic leaves over the fermenting surface and sometimes pouring melted fat from caribou, moose, or bear on top of the berries, which then hardened into an airtight seal, in order to prevent air from penetrating the berries (Spray, Winter 2002)(pp.37-38).

Food Refinement: Preparation and Cooking

General overview. The Inuit have five different ways of processing foods "igunak (fermented through partial decomposition), aranaq (fermented in oil); frozen (quaq); with rancid seal oil (misiraq); and above all mikijjipuk, uujungituk (raw)" (Searles, 2016)(p.29), and there is particular emphasis placed on eating an Inuit diet or specific Inuit foods (Stern & Stevenson, 2006)(p.142). They consume the vast majority of their food raw or dried (Brox et al., 2001). Food was cooked in an area adjacent to the living quarters because the igloos (low, rounded sod houses) were vulnerable to open flames. In the winter time, a dish filled with seal oil was used to reheat previously cooked, dried, or fermented food. Women and children spent most of the summer hours cooking foods and preserving foods for the coming winter months; whereas, during the winter, almost all cooking and food preservation ceased (Spray, Winter 2002)(pp.32-33).

Poaching was the most common technique used for preparing food due to having a limited heat source, which resulted in bland, if consistently flavored, food (Spray, Winter 2002)(p.36). Meat is boiled in water with the lowest salt concentration using water melted off of freshwater icebergs) because the Inuit are particularly sensitive to the taste of salt. This is likely a result of an evolutionary process intended to protect Inuit against

overconsuming salt in their salt-rich environment (Hladik & Simmen, 1996).

Roasting was typically only used for food Inuit were consuming immediately, otherwise, roasting was rare because having a charred exterior would impart a bitter taste to preserved foods and spit-roasting fish could result in the fish (if overcooked) falling into the ashes of the fire (Spray, Winter 2002)(p.37).

Tools. The ulu were the traditional utensils for preparing foods and were small, designed for women's hands. They were carved from stone or jade, had a seven inch wide blade that was shaped into a half sphere with an ivory or wood handle. The ulu was used for everything from sewing and fashioning caribou sinews into thread to cutting blubber from sealskins and cleaning fish for drying. Occasionally women used a two-inch wide ulu for sewing. The skinning board, a 15x18 inch board, was used to cut fat from sealskins. Carved wooden tools were used for stirring and mashing foods and poke blowers used to blow air into pokes were made from small, hollow bones or ivory. Cooking pots were made of dried clay and were set next to the fire when cooking food to prevent cracking (Spray, Winter 2002)(p.33).Women also used a dish filled with seal oil to reheat foods inside the igloo. This dish was an important part of Inuit society and the wife's sole property

Animals

Seal. "What unified the cuisine was the flavor of seal oil, the Eskimo's salt and pepper. Seal touched nearly every food, either in its preparation, as a preservative during storage, or as a final seasoning" (Spray, Winter 2002)(p.32). Dissimilar to Western cooking, Eskimos render seal oil without heat, rather, they store blubber in jars and allow gravity to cause the oil to slowly ooze out of the blubber (Spray, Winter 2002)(pp.38-39).

Whale. Two highly prized foods are "koowahk (partially defrosted, previously frozen raw meat)" and "muktuk (whale blubber with the skin attached)". Muktuk (also known as maktak) was prepared by removing a thin membrane covering the blubber (which was used to start fires) and then trimming excess blubber from the skin to prevent spoilage and speed up the drying processing. The excess was put into storage containers to render the fat and the remaining meat was cut into strings of connected diamond shapes and dried for several days. The muktuk was then submersed in boiling water until easily pierced by a fork, at which point it was drained, cut into individual squares, and dried. The dried pieces were put into oil for storage. Whale flippers were hung up to drain off oil and blood and then were either fermented or

cooked. Whale flippers were considered good travelling food (Morseth, 1997)(p. 250).

Both koowahk and muktuk are eaten raw, sliced extremely thin in order to bring out the special flavor of the meat and to help the meat melt in the mouth, instead of requiring endless chewing (Spray, Winter 2002)(p.39). Whale meat and blubber were often fermented into a "sweet-and-sour delicacy for celebrations" (Spray, Winter 2002)(p.39). The whale heart, brain, lungs, and head were eaten shortly after capture to avoid spoilage. The heart was boiled fresh or dried slightly and then cooked. The lungs were thinly sliced, hung to dry halfway, and then eaten with oil. The brains were eaten fried. Any extra brains were fed to the dogs, along with the rest of the head (Morseth, 1997)(p.250).

Whale bones were treated five different ways: "1) preserved with tissue still attached (flippers and ribs), 2) used in cooking at the camp site (tail and sternum), 3) removed for oil extraction (mandibles), 4) given to the dogs, or 5) burned" (Morseth, 1997)(pp.250-251). The oil extracted from the mandibles was used as gun oil or as a medicinal rub for relieving congestion (Morseth, 1997)(pp.250-251).

Other sea mammals. Igunaq is a method used by the Inuit for prepared meat, particularly walrus. Meat and fat

caught in the summer are cut into steaks and buried in the ground where they decompose and ferment in the autumn and then freeze over winter. The Inuit then eat the meat the following spring/summer (Wikipedia, “Igunaq”). Walrus liver was used to create a broth by cooking the liver in water, removing the liver and thickening the broth until it had a sauce-like consistency. This broth was then set aside for a couple of weeks, or until it was a little sour, and was used as a dipping sauce for seal (Spray, Winter 2002)(p.37).

Caribou and other land mammals. After a long day of hunting, caribou heads were roasted over a fired and then consumed. The Inuit consumed everything, include the base of the tongue and the brain (Stefansson, 1913)(pp.358-359). The fat of land mammals was rendered using gentle heat over an open fire (Spray, Winter 2002)(p.39). The Inuit also made a type of cheese from caribou called qisaruag, which was created by the stomach of a young caribou who was still nursing from its mother (Searles, 2016)(p.29). Bear meat was boiled, cooled, and eaten with seal oil to add flavor (Spray, Winter 2002)(p.37).

Dovekie. Freshly caught dovekie were often eaten raw upon capture or were boiled prior to consumption (Johansen, 2013). Frozen dovekie were consumed whole, in their frozen state, with the Inughuit sucking the skin

free of fat before swallowing the bird whole (Johansen, 2013)(p.83).

Plants

Greens. The Inuit eat the leaves or stems of greens (raw or cooked) and the roots, cooked. These greens provide a good source of vitamin C and beta-carotene (Turner, 1981)(pp.2341-2342). The Inuit will eat plants dipped in seal oil, with meat or fish, or with fish eggs and livers. They will also boil the plants and freeze them alone or with other greens or made into a juice (Kuhnlein, 1991)(p.220).

Berries. The Inuit consume berries fresh or stored frozen and eaten with seal blubber or oil. "Eskimo ice cream" (Akutaq) is a treat in which Eskimos serve berries mixed with seal oil and caribou tallow beaten to the consistency of whipped cream (Porsild, 1953)(p.21). The Eskimos living along the Bering Sea coast also brewed berries as a tea beverage (Kuhnlein, 1991)(pp.163-164).

Seaweeds, Lichen, and Mushrooms. Western Eskimos used lichen, including reindeer "moss" (*Cladina rangiferina*) and Arctic kidney lichen (*Nephroma arcticum*), among others, to flavor soup, to consume alone or as stomach contents of caribou, or boiled with crushed

fish eggs. Lichen from the partially digested stomach contents of caribou or other ungulates was often mixed with other lichens, grasses, willow, birch, etc., and other plant foods and served as a delicacy (Kuhnlein, 1991)(pp.37-38).

Roots and Tubers. Tubers were eaten raw or cooked (Turner, 1981)(p.2339), fermented in barrels with water, eaten with oil and sugar, or served with seal oil (Kuhnlein, 1991)(p.224).

Grains. Paluraq ("bread flours"), a bannock made with wheat flour, baking powder, milk powder, and shortening or butter (if available, otherwise, back fat of a caribou or seal blubber were used), was cooked on top of the stove in an iron skillet (Searles, 2016)(p.31).

Sharing and culture related to food

Eating Customs. The Inuit eat two main meals per day but will snack in between. During meals, large slabs of meat, blubber, and other animal parts are placed on a piece of metal, cardboard, or plastic on the floor. Anyone is welcome to cut off a piece of meat, but no one is required to eat. Dining etiquette is simple, with people eating whenever they're hungry and eating as much, or as little, as they would like to eat. The Inuit believe that eating without restraint honors and respects the animals

that have been caught by the hunter. The “Inuit have strong injunctions against wasting food” and wasting or refusing to share food brings public shame and bad luck (Searles, 2016)(p.30). During communal meals, other than post-hunt meals, only people who are hungry eat and men generally eat with their wives and children (Borre, 1991).

The Inuit use beluga meat as a way to define gender roles and emphasize co-dependency of males and females in Inuit society. As such, when dividing beluga meat into portions, some are eaten only by men and others are eaten only be women (Freeman, 1998)(p.66). Dining habits after the hunt are different from normal meals. Upon returning from the hunt, the hunters eat first, typically consuming the liver and seal blood, because they have the greatest need to re-nourish themselves. The women and children eat after the hunters, typically choosing the intestines first, then consuming any leftover pieces of liver. The ribs and backbone are the last parts of the seal to be eaten and any remaining meat is distributed to the camp (Borre, 1991). Additionally, in the Western Arctic, after a successful hunt, the first whale captured is distributed equally among everyone at the camp. Subsequent whales are distributed to members of the hunting group who then distributing the food to families and other community members (Freeman, 1998)(p.66). Additionally, in contrast to their day-to-day and other communal meal customs, during communal, post-hunt

meals, everyone was expected to eat, whether they were hungry or not (Borre, 1991).

Sharing. “Sharing food is a basic ethic in Inuit society, and instills a feeling of social solidarity. A sense of community, fostered by widespread sharing, remains important in small and often remote communities where the necessities of life may sometimes be in short supply” (Freeman, 1998)(p.32). According to Uqalurait: An Oral History of Nunavut, "food sharing was necessary for the physical and social welfare of the entire group." Younger couples gave food from their hunt to their elders as a sign of respect. Food sharing was a way for families to bond and the Inuit believed the sharing food with someone resulted in a lifelong partnership with them (Bennett, Rowley, & Barker, 2013). Additionally, food sharing occurs among the entire community, not just within or between individual families. Foods, and other objects associated with hunting, fishing, and gathering, are considered communal property and are for anyone who is in need of the food and is not meant to be saved for the person or family who obtained the food (Searles, 2016). Sharing of mattak in particular is essential to the Inuit cultural survival and “creates and sustains bonds that remain the basis of the Inuit social and economic relationships in the North today” (Freeman, 1998)(pp.29-30).

Religious beliefs in relation to hunting and consuming food. The Inuit's belief in the relationship between themselves and the seal is particularly strong. Inuit hunters and elders believe there is an agreement between seals and hunters that "allows the hunter to capture and feed from the seal" and "both hunter and seal are believed to benefit: the hunter is able to sustain the life of his people by having a reliable source of food, and the seal, through its sacrifice, agrees to become part of the body of the Inuit". They believe that if they do not respect this agreement, the animals will cease to reproduce and will disappear because they are offended by the actions of the Inuit (Borre, 1991). When hunting seals, the Inuit offer the seals a drink of fresh water as they die, which is considered a sign of respect and gratitude for the seal's sacrifice (Bennett et al., 2013). Similarly, after capturing a beluga whale, hunters put some of the blood back in the ocean and also return some liver, the head and organs (except the heart) to the sea to ensure that the animals will return again (Freeman, 1998)(p.40). As mentioned previously, the Inuit also believe that eating seal, particularly seal blood, is essential to health and often attribute sickness to a lack of seal in the diet (Borre, 1991). "Life and health require the linkage of both body (timuit) and soul (tanniq), aspects of the person that are united through social actions. Animals, especially seals, are said to give life to both the body and the soul of humans" (Borre, 1991).

Culture and hunting. Whale hunting among the Inuit fulfills social, economic, and cultural, needs, with whaling linking the Inuit spiritually and symbolically to their cultural heritage. Whaling is one of the most important collective hunting activities in Inuit communities and reinforces collective rights and social relationships, responsibilities, and obligations. Not surprisingly, Inuit whaling captains are highly respected leaders who are expected to both lead their crew during hunts and to lead the community in ceremonies. These captains are often the eldest and most experienced hunters (Freeman, 1998)(pp.29-30). "In Alaska, hunting of the large bowhead and gray whale has resulted in a highly elaborate whaling culture in which the organization of boat crews reinforces kin relations within and between families and households in the community. This serves to link members of communities into effective networks that strengthen cooperation and social solidarity" (Freeman, 1998)(p.31).

Birth, death and murder. Some researchers report that the Inuit resorted to infanticide in extreme cases of famine. Others suggest that female children were specifically killed to maintain a balance of males to females in society and because males were more valuable due to their ability to hunt. However, a brief examination of the sources of this belief suggests that there is only

limited support for the idea that the Inuit practiced infanticide. Additionally, the previously pervasive belief that the Inuit practiced senicide (killing the elderly) when food resources were low, has been proven untrue. Elders are revered due to their vast knowledge of Inuit culture and there are cultural taboos against sacrificing elders.

Trade. The Inuit began trading around 1 AD when East Asian traders sailed up the Pacific coast. The Inuit traded fur and walrus ivory for iron and steel knives. Around 1000 AD, Vikings arrived in Greenland and Inuit fur traders migrated east across Canada and settled in Labrador, Newfoundland, and Greenland to take advantage of this new trade opportunity. The Little Ice Age (around 1350 AD) resulted in fewer Vikings sailing to Greenland to trade and by 1408 AD the Vikings abandoned their last settlement in Greenland, effectively killing Inuit trade (Carr, 2017).

In the more recent past, Inuit communities traded with one another and with other Indian groups at regularly held summer trade fairs. The Inuit who lived below the Arctic Circle began trading with Russian fur traders after Vitus Bering met the Inuit of Alaska in 1741. The northern Inuit were not affected by the Russian fur trade but later became involved in the whaling trade. However, following the United States' purchase of Alaska in 1867, the Inuit whale traders were no longer needed due to

increases in whaling operations and the advent of steam-powered boats. Similar to the negative effects of trade on other native peoples, the emergence of trade outside of Inuit communities led to the introduction of new diseases and alcohol by Europeans. Disease and alcohol destroyed entire communities and greatly reduced Inuit populations of the inland areas (the Nuuamiut). During the 1920s the Inuit traded fox fur as a means of providing additional subsistence but this only lasted until the early 1930s, by which point the U.S. government was setting up post offices and providing money and relief agencies to the Inuit (Jones, 2017).

Division of labor among men and women. Men in Inuit society are the primary hunters and women traditionally care for children, clean, sew, process food, and cook; however, one woman in each family typically joins in community hunts or holiday hunts. Women fish with men and "both men and women consider women's efforts in subsistence as significant" (Borre, 1991). Even elderly women who are too frail to hunt or fish stay nearby and gut and filet fish as they are pulled from the river so that they are ready to be dried (Spray, Winter 2002)(p.36). Similarly, during beluga hunting season, butchering is done by both men and women in order to prevent spoilage (Morseth, 1997)(p.249). Women also harvest plant resources while men are hunting (Griffin, 2001). One researcher made the following observation about the role

of women in Eskimo society: “The Eskimo women are the greatest Drudges upon the face of the Earth. “They do everything except procure food, and even in that they are frequently assistants so that they are at continual labour. They sew with the sinews of deer and their needlework is amazingly exquisite” (Stopp, 2009). Men and women in Inuit society were co-dependent: “women are extremely busy…the rhythm of their work is dependent on that of the men. But the men are also dependent on the pace of women's work. A man cannot hunt until his parka is finished, nor can he move his family to spring camp until his wife has finished making the tent” (Stopp, 2009).

Marriage/Divorce. The seal oil dish, which was used to reheat foods inside the igloo, was an important part of Inuit society and the wife’s sole property. Bringing her seal oil dish into the igloo established the marriage and removing the dish was the signal for divorce. Keeping the seal oil dish burning was believed to ensure good times and spiritual peace (Spray, Winter 2002)(p.33).

Ingestion

While there are not any unique adaptations related to the teeth, jaw, or mouth in the Inuit, it is clear that the Inuit tooth wear pattern is distinct due to their diet. Specifically, Inuit are required to use their teeth to chew through tough skin, such as raw seal-hide, which results

in the Inuit having heavier wear on their incisors and canines compared to their molars (Clement, Hillson, & Aiello, 2012). Along with using their teeth for eating, the Inuit also report using their teeth for softening rawhide for clothes, though women are more likely to use teeth as tools than men and researchers have found sex differences in tooth wear between Inuit men and women (Wood, 1992). This pattern of wear is similar to that of the Neanderthals (Clement et al., 2012). These similarities resulted in researchers comparing modern-day Inuit to Neanderthals in an attempt to better understand Neanderthal diet and other behaviors and to test the Anterior Dental Loading Hypothesis (ADLH) (Anton, 1990). The ADLH states that the unique Neanderthal facial and dental anatomy was a response to regularly applying heavy forces to the anterior teeth (Anton, 1990). Clement et al. stated that: "It has been proposed that this was the result of heavy use of the incisors and canines both for food preparation/mastication and as part of the toolkit in processing materials and/or producing artefacts and manipulating them" (Clement et al., 2012). However, Inuit-Neanderthal comparisons revealed that the Inuit exhibit incisor median wear ratios three to four times those of Neanderthals. These higher wear ratios suggest that the Inuit subject their teeth to stronger, more repetitive forces than did the Neanderthals. Overall, these findings do not support the ADLH (Clement et al., 2012).

Digestion

Seaweeds, Lichens, & Mushrooms. After long periods abstaining from seaweed, people often experienced stomach pains; however, after eating seaweed for a few days, they could eat it without stomach problems. These problems with the digestibility of seaweed aren't unique to the Inuit, but are related to the complex carbohydrates in seaweed, which require extensive process in order to digest (Kuhnlein, 1991)(p.27). Similarly, lichen polysaccharides are difficult to digest, but chronic consumption of lichen improves digestion. The Inuit custom of eating lichen found in the partially digested stomach contents of caribou improved the digestibility of the food, since the polysaccharides and proteins had already been partially digested in the animal's rumen (Kuhnlein, 1991)(pp.37-38). Inuit dislike of mushrooms may relate to trehalase deficiency, as mushrooms contain trehalose, and eating mushrooms would likely have caused a stomachache for those who were trehalase deficient, which is incident in 10-15% of the Greenland Inuit (Kozlov, Vreshubsky, Borinskaya, Sokolova, & Nuvano, 2005).

Raw versus cooked meat. Cooking meat denatures muscle fiber proteins and collagen, which causes the collagen to gelatinize and become more soluble (Bouton & Harris, 1972). This makes the meat more tender and

easier to chew (such as when cooking meat for stew). The effects of cooking meat on proteins and collagen, as well as the effects of chewing, make meat easier to digest (Bouton & Harris, 1972) and may increase the net amount of energy gained from eating meat, due to less energy being used for digestion and absorption (Boback et al., 2007), though data in this regard are still equivocal (Crittenden & Schnorr, 2017).

The cooking method used affects fat content of foods. For example, boiling fish preserves omega-3 fatty acid content more than frying or microwaving (Stephen, Jeya Shakila, Jeyasekaran, & Sukumar, 2010), with frying reducing omega-3 content by as much as 70-85% (Anastasios, Akylas, & Emmanouil, 2012; Stephen et al., 2010).

Direct assessment of carbohydrate in whale blubber indicates that carbohydrate content ranges from 8-30%, depending on the location of the blubber (Lockyer, 1991). Additionally, delayed onset of rigor mortis in marine mammals, due to the high oxymyoglobin content of their muscles, decreases the amount of glycogen depletion that typically occurs post-mortem (Lawrie, 2006)(p.92). Finally, glycogen depletion is halted at temperatures -18 degrees C and lower (Lawrie, 2006)(p.298). All of these reasons explain how the Inuit are able to consume

sufficient carbohydrates on a regular basis despite their diet primarily consisting of animal products.

Macronutrients in a traditional Inuit diet

Traditional Inuit diets are comprised of approximately 50% of calories from fat, 30-35% from protein, and 15-20% from carbohydrates, with carbohydrates primarily coming from glycogen in raw meat (Krogh & Korgh, 1915). Despite consuming a diet high in fat, Inuit diets do not pose the same health risks as high-fat Western diets because the fat in their diets primarily consist of mono-unsaturated and omega-3 fatty acids (Ho, Mikkelson, Lewis, Feldman, & Taylor, 1972). Aerobic cellular respiration differs in humans, such as Inuit, adapted to Arctic climates and those adapted to temperate climates. Specifically, humans adapted to temperate climates use carbohydrates as their main source of energy; whereas, those adapted to the Arctic primarily use lipids and derivatives of protein metabolism for energy, with endogenous glucose produced in the liver from amino acids (Kozlov et al., 2005). Blood glucose concentrations are not normally high as a result of producing endogenous glucose from amino acids (Kozlov et al., 2005). Even as recently as the 1980s, the daily consumption of sugar in Arctic natives only averaged about 67.2g/day and 48.8g/day in males and females, respectively, which was estimated as half that of Europeans and Russians (Kozlov

et al., 2005). “The diets of traditional Arctic populations are sometimes given as examples of successful high-protein diets” (Hardy, Brand-Miller, Brown, Thomas, & Copeland, 2015).

Fatty acid composition of traditional Inuit diets. Inuit diets consisting primarily of seal and whale blubber and meat are high in mono-unsaturated and omega-3 polyunsaturated fatty acids (MUFAs and PUFAs), with relatively small amounts of saturated fatty acids (SFAs) (Brox et al., 2001). Meat from cooked land animals and aged animals contain more SFAs than meat from sea mammals, grouse, or fish (Kuhnlein et al., 2002)(p.564). Land animals consumed by Inuit have higher amounts of omega-6 than omega-3 fatty acids, particularly 18:2n-6, 18:3n-6, and 20:4n-6. Sea mammals and fish tissues contained by eicosapentaenoic acid (EPA; 20:5n-3) and docosapentaenoic acid (DHA; 22:6n-3). Ringed seal, narwhal, and beluga blubber contained the most EPA and walrus and polar bear blubber contained the most DHA (Kuhnlein et al., 1991)(pp.231-233). Importantly, there are substantial health benefits, such as reduced chronic disease risk, associated with consuming EPA and DHA, which are the most significant omega-3 fatty acids in the Inuit diet (Kuhnlein et al., 2002)(pp.564-565). The omega-6 to omega-3 ratio in Inuit foods is approximately 0.26 and 0.29 for women and men, respectively, with the amount of MUFAs consumed at least double that of

PUFAs and SFAs (Kuhnlein et al., 1991)(p.233). SFAs were higher in land animal fats, with the highest amount in caribou fat. The primary SFAs were palmitic (16:0) and stearic (18:0) acids (Kuhnlein et al., 1991)(p.231).

Mean consumption of marine foods in one study 131.2 g/day. Average daily intake of EPA, DHA, and EPA+DHA in traditional Inuit foods (mattak, red char, ringed seal, etc.) are 1020.7, 1093.9, and 2114.5 mg, respectively. Maximum mean daily intake of EPA+DHA is 34.8 g/day. Omega-3 fatty acid intakes are higher among the Inuit than other populations (Dewailly et al., 2001). The predominant fatty acids in seal oil are 18:1n-9 (oleic acid) (19.6%), 16:1n-7 (palmitoleic acid) (11.6-12.1%), DHA (10.5%), 20:1n-9 (gondoic acid) (9.6-10.2%), 16:0 (palmitic acid) (7.6%), EPA (7.2-7.4%). Also, seal oil is composed of 13.1-13.7% saturated fat, 48.4-48.6% monounsaturated fat, 25.7-26.3% polyunsaturated fat with a ratio of n-3/n-6 of 13.5-13.8 (Kuhnlein et al., 1991)(pp.231-233).

The following foods have greater than 90% of calories from fat: raw blubber and raw fat from ringed seal, narwhal, walrus, beluga whale, caribou, and polar bear. Arctic chair and ringed seal brain have 59% of calories from fat. The following foods have 20-30% of calories from fat: ringed seal eyes and liver, ringed seal pup meat, bearded seal intestines, narwhal and beluga mattak, raw

caribou meat, raw polar bear meat, and raw ptarmigan. Plant-based foods, such as blackberries and kelp, have less than 20% of calories from fat. These calculations are based on data from Kuhnleing and Soueida (Kuhnlein et al., 1991)(p.118)(see table named “Macronutrient composition of common Inuit foods”).

The three tables below show the fat content (in grams or mgs per 100g of the food) of common Inuit foods. Unfortunately, there do not appear to be any published studies or summaries of the precise percentage in the Inuit diet of SFA, MUFAs, and PUFAs; though, the estimates above are likely representative of a typical Inuit diet. A substantial amount of calculations would be required to determine more detailed information due to the fact that the available data are per 100 grams of a food, without any total caloric information.

TABLE 4a

Saturated and monounsaturated fatty acids in samples of sea mammals, land animals, birds and fish traditionally used for food by Inuit and Yukon communities (g/100 g) (mean and S.D.)

Common name[1]	n[2]	Saturated fatty acids									Monounsaturated fatty acids						
		8:0	10:0	12:0	14:0	16:0	18:0	20:0	22:0	24:0	12:1	14:1	16:1	18:1	20:1	22:1	24:1
Sea mammals																	
Bearded Seal																	
Meat, boiled	1	nd[3]	nd	nd	0.2	0.6	0.2	nd	nd	nd	nd	nd	0.2	0.9	0.9	0.1	nd
Beluga																	
Muktuk, boiled	1	nd	nd	0.2	1.0	1.1	0.2	nd	nd	0.3	tr[4]	0.4	3.8	3.8	1.5	0.1	nd
Oil	1	nd	nd	0.5	5.5	10.7	2.4	nd	nd	4.7	nd	0.5	14.7	21.1	13.8	1.8	3.0
Land animals																	
Caribou																	
Meat, cooked	1	nd	nd	nd	0.1	1.4	1.0	nd	nd	0.1	nd	nd	0.1	1.7	nd	nd	nd
Meat, raw	2	nd	nd	nd	tr	0.2(0.03)	0.1(0.04)	nd	nd	tr	nd	tr	tr	0.2(0.05)	nd	nd	nd
Meat, raw aged	1	nd	nd	nd	tr	0.7	0.5	nd	nd	0.1	nd	tr	0.1	0.9	nd	nd	nd
Moose																	
Fat, raw	2	tr	tr	tr	0.7(0.46)	13.2(2.67)	nd	0.5(0.20)	0.1(0.05)	0.1(0.05)	nd	tr	0.6(0.11)	52.8(3.66)	0.5(0.03)	tr	nd
Liver,raw	1	nd	nd	nd	tr	0.2	0.3	tr	nd	nd	nd	tr	tr	0.2	tr	nd	nd
Rabbit																	
Meat, cooked	1	nd	nd	nd	0.2	1.4	0.4	nd	nd	0.1	nd	tr	0.4	0.6	nd	tr	nd
Meat, raw	1	tr	tr	tr	tr	0.4	0.1	nd	tr	tr	nd	tr	tr	0.2	tr	tr	nd
Birds																	
Grouse																	
Meat, raw	2	nd	nd	tr	tr	0.1(0.08)	0.1(0.02)	tr	tr	nd	nd	tr	tr	0.1(0.12)	tr	nd	nd
Fish																	
Cod																	
Flesh, raw	1	nd	nd	nd	tr	0.1	tr	nd	nd	tr	nd	tr	tr	0.1	tr	nd	tr
Grayling																	
Flesh, raw	1	nd	nd	tr	tr	0.3	0.1	nd	nd	tr	nd	nd	0.1	0.4	tr	nd	nd
Loche																	
Eggs, raw	2	nd	nd	nd	0.1(0.01)	0.7(0.06)	0.1(0.05)	tr	nd	0.4(0.16)	nd	nd	0.8(0.25)	2.1(0.70)	0.4(0.33)	tr	nd
Pike																	
Flesh, cooked	1	nd	nd	nd	tr	0.2	0.1	nd	nd	nd	nd	nd	0.1	0.2	tr	nd	nd
Flesh, raw	1	nd	nd	nd	tr	0.1	tr	nd	nd	tr	nd	tr	tr	0.1	nd	nd	nd
Trout																	
Flesh, raw	2	nd	tr	tr	0.2(0.28)	0.6(0.71)	0.1(0.15)	tr	tr	tr	nd	tr	0.3(0.39)	0.9(1.1)	tr	tr	nd
Salmon																	
Eggs, raw	2	nd	nd	tr	0.4(0.06)	1.5(0.00)	0.4(0.00)	nd	nd	nd	nd	tr	1.3(0.17)	3.8(0.026)	0.2(0.06)	tr	nd
Flesh, cooked	2	nd	nd	tr	0.2(0.06)	0.6(0.07)	0.2(0.01)	tr	tr	tr	nd	tr	0.3(0.14)	1.4(0.08)	0.6(0.08)	0.1(0.08)	tr
Flesh, raw	3	nd	nd	tr	0.1(0.04)	0.3(0.16)	0.1(0.04)	tr	tr	tr	nd	tr	0.1(0.08)	0.7(0.47)	0.3(0.22)	tr	tr
Flesh, smoked	3	nd	nd	tr	0.3(0.14)	1.2(0.47)	0.3(0.16)	tr	nd	tr	nd	tr	0.5(0.30)	2.2(1.40)	1.3(0.73)	0.1(0.04)	0.1(0.03)

[1]Cooked noted in the preparation refers to one of several methods: baked, boiled, poached (for some fish) or roasted. Smoked also includes smoke/dried samples.
[2]Samples of current surveys only.
[3]Not detected.
[4]Trace amounts <0.05 g/100 g.

TABLE 4b

Omega-3 and omega-6 polyunsaturated fatty acids in samples of sea mammals, land animals, birds and fish traditionally used for food by Inuit and Yukon communities (g/100 g) (mean and S.D.)

Common name[1]	n[2]	n-3 polyunsaturated fatty acids					n-6 polyunsaturated fatty acids						
		18:3n-3	20:3n-3	20:5n-3	22:3n-3	22:6n-3	18:2n-6	18:3n-6	20:2n-6	20:3n-6	20:4n-6	22:2n-6	22:4n-6
Sea mammals													
Bearded seal													
Meat, boiled	1	nd[3]	nd	0.1	nd	0.1	0.1	nd	nd	nd	0.1	nd	nd
Beluga													
Muktuk, boiled	1	nd	nd	0.5	nd	0.7	0.1	0.1	nd	nd	0.1	nd	nd
Oil	1	0.1	nd	5.8	0.1	7.4	0.9	0.4	0.2	nd	0.4	nd	0.1
Land animals													
Caribou													
Meat, cooked	1	nd	nd	0.1	nd	nd	0.6	0.2	nd	nd	0.3	nd	nd
Meat, raw	2	nd	tr[4]	tr	tr	nd	0.1(0.02)	tr	nd	nd	0.1(0.01)	nd	nd
Meat, raw aged	1	nd	nd	tr	nd	nd	0.3	0.1	nd	nd	0.2	nd	nd
Moose													
Fat, raw	2	0.3(0.09)	0.1(0.03)	tr	nd	tr	1.9(0.66)	1.5(0.59)	0.1(0.00)	0.1(0.00)	tr	tr	nd
Liver,raw	1	tr	tr	tr	tr	tr	0.1	0.1	tr	tr	0.1	nd	nd
Rabbit													
Meat, cooked	1	tr	tr	tr	nd	nd	0.9	0.2	nd	nd	0.2	nd	nd
Meat, raw	1	tr	tr	tr	nd	nd	0.2	tr	tr	tr	tr	nd	nd
Birds													
Grouse													
Meat, raw	2	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	nd	nd
Fish													
Cod													
Flesh, raw	1	tr	tr	0.1	tr	0.2	tr	tr	tr	tr	tr	nd	tr
Grayling													
Flesh, raw	1	tr	nd	0.1	nd	0.1	0.2	0.1	tr	nd	tr	nd	nd
Loche													
Eggs, raw	2	tr	tr	1.2(0.68)	0.1	1.8(0.38)	0.2(0.01)	0.1(0.05)	tr	tr	0.3(0.11)	nd	0.1(0.02)
Pike													
Flesh, cooked	1	tr	nd	0.1	nd	0.1	tr	tr	nd	nd	0.1	nd	nd
Flesh, raw	1	nd	nd	tr	tr	0.2	tr	tr	nd	nd	tr	nd	tr
Trout													
Flesh, raw	2	tr	tr	0.2(0.17)	tr	0.6(0.65)	0.1(0.14)	0.1(0.13)	tr	tr	0.1(0.06)	tr	tr
Salmon													
Eggs, raw	2	tr	tr	1.1(0.14)	nd	1.3(0.18)	0.1(0.01)	tr	tr	tr	0.1(0.00)	nd	nd
Flesh, cooked	2	tr	tr	0.5(0.05)	tr	0.8(0.13)	0.2(0.15)	0.1(0.08)	tr	tr	tr	tr	tr
Flesh, raw	3	tr	tr	0.2(0.08)	tr	0.3(0.16)	tr	tr	tr	tr	tr	tr	tr
Flesh, smoked	3	tr	tr	0.5(0.09)	nd	1.0(0.26)	0.1(0.04)	tr	tr	tr	0.1(0.01)	tr	tr

[1]Cooked noted in the preparation refers to one of several methods: baked, boiled, poached (for some fish) or roasted. Smoked also includes smoke/dried samples.
[2]Samples of current surveys only.
[3]Not detected.
[4]Trace amounts <0.05 g/100 g.

TABLE 1
The Fatty Acid Composition (weight percent) of Cod-Liver Oil and Seal Oil

	Cod-liver oil[a]		Seal oil[a]	
	Entry	14 mon	Entry	14 mon
Fatty acid				
14:0	3.8	3.6	5	5
16:0	9.4	9.2	7.6	7.6
18:0	2.1	1.9	0.5	1.1
Sum	15.3	14.7	13.1	13.7
16:1n-7	7.9	7.2	12.1	11.6
18:1n-9	17.1	17.2	19.6	19.6
18.1n-7	4.2	3.6	3.2	2.9
20:1n-9	10.9	11.5	9.6	10.2
22:1n-11	5.3	5.9	3.5	3.9
22:1n-9	0.5	0.5	0.4	0.4
Sum	45.9	45.9	48.4	48.6
18:2n-6	1.8	1.7	1.9	1.9
18:3n-3	1	0.9	1	0.9
18:4n-3	3	2.7	3.5	3.2
20:5n-3	10.1	9.7	7.4	7.2
22:5n-3	1.2	1.2	3.9	3.9
22:6n-3	11.9	12.1	10.5	10.5
Sum	27.2	26.6	26.3	25.7
n-3/n-6	15.1	15.6	13.8	13.5
Rest (unidentified)	9.8	11.1	10.3	10.1

[a]The oils were kept at 4°C.

(Kuhnlein et al., 1991)(pp.231-233)

Protein. Protein content of uncooked meats varies from 21-26g/100g. Bearded seal meat provides the greatest percent of calories from protein, 83%, with ringed seal heart and meat providing about 81% of calories from protein. Walrus meat and mattak have 81% and 77% of calories from protein, respectively. Sculpin has 78% of calories from protein. Ringed seal liver, eyes, and brain

provide 70%, 63%, and 37% of calories from protein, respectively. Polar bear and caribou meat provide 76% and 69% of calories from protein. Animal blubber and plant foods, except mountain sorrel (30%), provide less than 5% of calories from protein (Kuhnlein et al., 1991).

There is not information about whether this protein is complete or collagenous. However, it is reasonable to assume that the vast majority of this protein is complete, particularly protein in brain, liver, eyes, or blubber. Protein from meat likely has some collagenous content due to the skin remaining attached is some cases-this is definitely the case in mattak, based on how mattak is made; however, no data are present to indicate the relative contribute of complete versus collagenous protein. From a nutritional perspective, there is no difference in the digestion, absorption, metabolism, or use of the protein in the body, because protein is broken down into individual amino acids, dipeptides, or tripeptides prior to absorption. Di- and tri-peptides are hydrolyzed into free amino acids in intestinal enterocytes, and it is the individual amino acids that are used in the body, not whole proteins.

Macronutrient composition of common Inuit foods (Modified from Kuhnlein and Soueida (Kuhnlein et al., 1991))							
Food	**Protein (g)**	**Fat (g)**	**CHO (g)**	**Total Kcals**	**Protein (%**	**Fat (%**	**CHO (%**

					calories)	calories)	calories)
Ringed seal-raw meat	25	1.7	0	123	81.30	12.44	0.00
Ringed seal-raw blubber	2.8	90	0	823	1.36	98.42	0.00
Ringed seal-liver	24	3.9	0.5	138	69.57	25.43	1.45
Ringed seal-heart raw	23	1.9	0	113	81.42	15.13	0.00
Ringed seal-brain raw	14	9.9	0	150	37.33	59.40	0.00
Ringed seal-eyes raw	11	2.3	0.5	70	62.86	29.57	2.86
Ringed seal pup-raw meat	21	2.8	0	115	73.04	21.91	0.00
Bearded seal-raw meat	25	1.4	0	121	82.64	10.41	0.00
Bearded seal-raw intestine	19	2	0	100	76.00	18.00	0.00
Narwhal-raw blubber	5.3	81	0	754	2.81	96.68	0.00
Narwhal-mattak-raw	23	3	1.1	130	70.77	20.77	3.38
Beluga-raw mattak	27	4.2	0.8	154	70.13	24.55	2.08

Beluga-raw blubber	10	66	0	640	6.25	92.81	0.00
Walrus-raw meat	24	1.9	0	119	80.67	14.37	0.00
Walrus-raw blubber	5.9	80	0	746	3.16	96.51	0.00
Walrus-raw mattak	33	3	0	171	77.19	15.79	0.00
Polar bear-raw meat	22	2.5	0	116	75.86	19.40	0.00
Polar bear-raw fat	3	82	0	756	1.59	97.62	0.00
Caribou-raw meat	24	4	0	140	68.57	25.71	0.00
Caribou-fat raw	2.7	90	0	824	1.31	98.30	0.00
Caribou-stomach contents raw	7.4	1.7	11.4	91	32.53	16.81	50.11
Arctic char-meat-dried	28	20	0	302	37.09	59.60	0.00
Sculpin-whole, raw	18	1.5	0	92	78.26	14.67	0.00
Ptarmigan-raw	25	3.3	0	135	74.07	22.00	0.00
Kelp	2	0.9	14.7	69	11.59	11.74	85.22
Blackberries	0.5	1	10.9	50	4.00	18.00	87.20

Mountain sorrel	3.8	0.9	7.6	51	29.80	15.88	59.61

Carbohydrate. Despite the predominance of animal foods in the Inuit diet, the Inuit consume more carbohydrates than one would expect because of their food preparation practices (Hui, 1985). Their tradition of eating meat raw and fresh, or recently frozen, allows glycogen in the meat to remain intact, in contrast to Western diets in which cooking of meat products breaks down glycogen (Hui, 1985; Rabinowitch, 1936). Additionally the practice of preserving an entire animal carcass under intact whale skin with a thick layer of blubber results in protein fermentation and hydrolysis into carbohydrates (Hui, 1985). Marine mammals also have significant glycogen stores to assist in prolonged underwater dives, also increasing carbohydrate content of their meat, blubber, organs, and skin (Lockyer, 1991). Finally, in cold conditions, glycogen depletion halts at -18°C (-0.4°F) and lower temperatures in comminuted meat (Lawrie, 2006).

The best sources of carbohydrate in the traditional Inuit diet are blueberries, blackberries, and kelp, which provide 96%, 87%, and 85% of calories from carbohydrates, respectively. Cloudberries and rhubarb have 67% and 65% of calories from carbohydrates, respectively. Mousenut, mountain sorrel, fireweed, and sourdock each

have about 60% of calories from carbohydrate. The stomach contents of caribou are also a good source of carbohydrates due to the contents consistent of plant matter, such as lichen. As such, caribou stomach contents have 50% of calories from carbohydrates. Some forms of mattak, such as narwhal and beluga, provide a small percent of calories from carbohydrates (3% and 2%, respectively) (Kuhnlein et al., 1991). See table above.

Micronutrients in a traditional Inuit diet

Vitamin A. The best sources of vitamin A (retinol) in the Inuit diet are beluga blubber and oil, narwhal blubber, and ringed seal, walrus, caribou, moose, and loche liver, with means greater than 1500 micrograms/100 grams of meat (Kuhnlein et al., 2006). Beluga meat and mattak, narwhal mattak, seal blubber and meat, walrus blubber and meat, caribou bone marrow and kidney, and polar bear flesh are moderate sources of retinol, containing a mean >100 and <1500 micrograms/100g. According to Kuhnlein et al, "the most frequently consumed Arctic foods are caribou flesh, ringed seal flesh with blubber and arctic char (Kuhnlein et al., 2002). While these items are low in vitamin A, the extent of consumption makes them reasonable sources when combined with infrequent higher sources" (Kuhnlein et al., 2006). Fireweed contains a moderate amount of vitamin A in the form of beta-carotene (828 IUs, 17% DV). Other plant-based foods

contain only small amounts of cloudberries, blueberries, and other berries contain only trace amounts of beta-carotene. Kuhnlein et al.'s data suggest greater consumption of traditional Inuit foods results in greater vitamin A consumption. Additionally, only 7-22% of Inuit men consume below the EAR for vitamin A (which is 625 micrograms/day); whereas, 77-47% of women consume below the EAR (which is 500 mcg/day). These rates are lower in Yukon First Nations women and younger men, 15% and 0%, respectively, below the EAR. Only 3 and 7% of older women and men, respectively, exceed the UL of 3000 mcg/day, likely due to their greater consumption of traditional foods (Kuhnlein et al., 2006).

Vitamin D. The best sources of vitamin D (cholecalciferol) in the diet were from beluga blubber and oil, narwhal blubber, ringed seal liver, arctic char flesh, cisco eggs, lake trout flesh, loche eggs and liver, and sculpin, with means greater than 5 micrograms/100 grams. The AI for younger men and women is 5 mcg/day and is 10mcg/day for older individuals. However, all Arctic sea mammal fats and fish were good sources of vitamin D (Kuhnlein et al., 2006). The rich sources of vitamin D in traditional Inuit foods protect them from inadequacy because mean intakes are well above the adequate intake (AI) for adults, and even consuming only 28% of calories from traditional foods is sufficient to

achieve the AI. Young and old Inuit males and females have intakes exceeding the AI for vitamin D and 17% of older Inuit men exceeded the UL (50 mcg/day) (Kuhnlein et al., 2006).

Vitamin E. The best sources of vitamin E (alpha-tocopherol) are beluga fat, narwhal fat, walrus flesh and muktuk, and caribou liver, with means greater than 10mg/100g. Seal intestine, beluga muktuk, narwhal muktuk, seal blubber, caribou fat, flesh, and stomach, polar bear flesh, ptarmigan flesh, and kelp are other good sources of vitamin E. Though some foods provide vitamin E, Kuhnlein et al.'s data suggest that the majority of Inuit individuals consume inadequate vitamin E in their diets (mean of >0.5 to <10 mg/100g) (Kuhnlein et al., 2006).

Vitamin C. Despite eating a diet low in plant foods, the Inuit are able to consume the minimum vitamin C intake required to prevent scurvy from traditional foods, namely, frozen/raw, fermented, and dried animal foods (Fediuk et al., 2002). Some of the best sources of vitamin C are raw caribou liver (24 mg), seal brain (15 mg), and raw kelp (28 mg) (Fediuk et al., 2002). These foods are good sources of vitamin C because they contain collagen, and because "traditional Inuit practices like freezing meat and fish and frequently eating them raw, conserve vitamin C, which is easily cooked off and lost in food processing" (Gadsby & Steele, 2004). "Danish and Norwegian

physicians and scientists were among the first to study the nutritional value of the Inuit diet. Among their findings was the conclusion that whale mattak, long known to provide excellent protection against scurvy, contains rich sources of vitamins A and C, thiamin, riboflavin, and niacin." (Freeman, 1998)(p.45).

Minerals in a traditional Inuit diet

Sodium and Potassium. Overall, the sodium content of traditional Inuit foods are highest in animal meats, with substantially lower quantities in blubber, mattak, and plant-based foods. Sodium content of foods is higher in dried and raw meats and mattak than in blubber. Sodium content of raw meat and mattak ranged from 41-200 mg/100g. The food sources with the highest amounts of sodium included seal eyes (230mg/100g), blubber and mattak from aged flippers of sea mammals (161-281mg/100g), caribou stomach contents (268mg/100g), raw mussels and clams (325 and 858mg/100g, respectively, and kelp (610mg/100g). Other plant foods are poor sources of both sodium (Kuhnlein & Soueida, 1992). Adults require 4700mg/day of potassium. Good food sources of potassium include dried caribou meat (1100mg/100g), clams (600mg/100g), ptarmigan (425mg/100g), and caribou heart (400mg/100g). Other lesser sources of potassium include whale skin, Arctic char, caribou meat, trout, seal meat, seal intestines, and

mussels, each with approximately 250-350 mg/100g. Traditional Inuit plant foods are not good sources of potassium.

Calcium and Phosphorus. The biggest sources of phosphorus include dried narwhal, beluga, and caribou meat (700mg, 582mg, and 621mg/100g, respectively. Walrus mattak has 28mg/100g. Ptarmigan, Arctic char skin, and sculpin contain 351mg/100g, 403mg/100g, and 415mg/100g of potassium. Ringed seal brains and caribou also have a fair amount of phosphorus, 305mg and 406mg/100g, respectively. The best sources of calcium in the Inuit food system are caribou stomach and stomach contents (240 and 98mg/100g, respectively). Other animal sources of calcium Arctic char skin (268mg/100g), whole sculpin with the bones (429mg/100g), boiled duck (141mg/100g), and raw and cooked clams (172 and 198mg/100g, respectively). Plant sources of calcium include kelp, sorrel, netted willow, and Arctic willow, with 160mg, 116mg, 267mg, and 188mg/100g, respectively (Kuhnlein & Soueida, 1992). Another study found that the best sources of calcium in a traditional diet were bearded seal intestine (58±26mg/100g), moose bone marrow (44±66 mg/100 g), bird flesh (30–45 mg/100 g), grayling flesh and salmon flesh and eggs (41–40mg/100g) (Kuhnlein et al., 2002)(p.564).

Magnesium. Freeman found that magnesium was predominantly present in smoked salmon, and potassium was high in meats and whale muktuk (Freeman, 1998)(p.47). Kuhnlein and Soueida found that the best animal sources of magnesium were meats (14-72mg/100g) and raw and cooked clams (107 and 122mg/100g, respectively). The best plant sources of magnesium were kelp (120mg/100g), netted willow (167mg/100g), and Arctic willow (89mg/100g) (Kuhnlein & Soueida, 1992).

Other micronutrients-Iron, zinc, copper, manganese, and selenium. The primary food sources of iron, zinc, copper, and manganese are red meats. The best sources of iron are dried narwhal, dried beluga, and dried caribou, with 70mg, 57mg, and 13mg/100g, respectively (Kuhnlein & Soueida, 1992). Fresh seal meat (22-28mg/100g), fresh walrus meat (19-22mg/100g), dried moose (11-18mg/100g), and liver (12-46mg/100g) are also good sources of iron. (Freeman, 1998)(p.47). The best sources of zinc include dried narwhal (7mg/100g), dried beluga (8.9mg/100g), dried caribou (7.2mg/100g), ringed seal eyes (30mg/100g) (Kuhnlein & Soueida, 1992) , and narwhal and beluga muktuk (7-8mg/100g) (Freeman, 1998). The best animal sources of copper include ringed seal liver, ringed seal eyes, dried caribou, Arctic char skin, duck, each contain 1.4mg, 1mg, 1mg, 1.1mg, and 2.4mg/100g, respectively). Plant sources of

copper include kelp (16mg/100g) and Arctic willow (12mg/100g) (Kuhnlein & Soueida, 1992). Animal sources of manganese include dried meats (0.05-0.17mg/100g), caribou stomach (10mg/100g), and caribou stomach contents (2.8mg/100g) (Kuhnlein & Soueida, 1992). Plant sources of manganese include mountain sorrel (1.74mg/100g), Arctic willow (2.9mg/100g) (Kuhnlein & Soueida, 1992), and berries (1.4-3mg/100g) (Freeman, 1998)(p.47). Good sources of selenium included narwhal and beluga muktuk (Freeman, 1998)(p.47), walrus meat, moose kidney and liver, and grayling flesh (Kuhnlein et al., 2002)(p.564).

Calcium, Phosphorus, Vitamin D and Bone Health. As previously mentioned, the traditional Inuit diet contains a substantial amount of vitamin D (Kuhnlein et al., 2006) which is important because the dark skin pigmentation of the Inuit, along with the latitude at which they live, reduces their ability to synthesize vitamin D via the cascade of metabolic responses to the sun's ultra-violet rays striking 7-dehydrocholesterol in the skin (Nelson, Agarwal, & Darga, 2015; Wallace, Nesbitt, Mongle, Gould, & Grine, 2014). Along with Inuit consuming a lot of vitamin D in their traditional diet, data suggest that Inuit have adapted to inadequate exposure to solar radiation (resulting in less vitamin D synthesis due to UVB exposure) via a genetic polymorphism in the vitamin D receptor gene at the BsmI site, such that a

much larger proportion of the Inuit population (compared to Euro-Americans) are homozygous for the b allele, which is associated with more efficient intestinal calcium absorption and less osteoporosis (Nelson et al., 2015). Additional data suggests that Inuit may also compensate for decreased vitamin D synthesis via increased conversion of vitamin D to its most active form in the body via the liver and kidneys (Frost, 2012). Importantly, Inuit may have low serum vitamin D but not exhibit symptoms of vitamin D deficiency (rickets in particular), suggesting that Inuit may have a lower inherent "set-point" for calcium-regulated parathyroid hormone release and/or enhanced renal vitamin D production (Rejnmark et al., 2004). It should be noted that other dark-skinned populations exhibit similar adaptations to lesser ability to synthesize vitamin D via sun-exposure (Sellers, Sharma, & Rodd, 2003).

Despite sufficient vitamin D intake and a lack of vitamin D deficiency in the form of rickets, data suggest Inuit have low bone mass and thinner cortices, lower bone mineral content, and increased remodeling and bone loss compared to U.S. whites (Nelson et al., 2015). Other data demonstrate age-related deterioration of bone diaphyseal

structure in Inuit and Inuit experience a greater severity of age-related bone loss than other groups (Wallace et al., 2014). Finally, Eskimos and Inuit have bone mass values that are 5-10% below age-matched Caucasians (Pfeiffer & Lazenby, 1994) and Eskimos lose bone at earlier ages and at a greater rate than other populations (Harper, Laughlin, & Mazess, 1984). Reasons for low bone mass and greater bone loss in Inuit remain unclear; however, some researchers believe this may be linked to high dietary protein intake. This is because high protein intake is associated with greater intake of phosphorus and the metabolic by-products of phosphorus metabolism result in increased blood acidity, which is typically buffered by calcium-resorption from the bone (Kerstetter, Brien, & Insogna, 2003). Another potential reason is the increase in urinary calcium associated with high-protein diets (Kerstetter et al., 2003). However, it is important to note that it is difficult to separate the effects of a high-protein diet from those of low dietary calcium or vitamin D status (Kerstetter et al., 2003).

In regards to dietary calcium intake, the traditional Inuit data often lacks sufficient calcium (Wallace et al., 2014). The combination of low dietary calcium with high dietary protein could be problematic, as data suggest that high protein intake (greater than about 1.5 g protein/kg body weight) results in increased calcium loss in the urine, with the calcium loss coming entirely from bone (Kerstetter et

al., 2003). Eskimos also appear to have a high occurrence of type II osteons, which are sites of rapid mobilization of skeletal calcium and is presumed to be consistent with the acidic nature of their high-protein diets (Pfeiffer & Lazenby, 1994). Despite these challenges, data suggest that darker-skinned humans, such as Inuit, may cope with lower calcium intake via increased calcium and phosphorus absorption (which is consistent with human physiology in general, in which calcium absorption changes based on calcium intake, such that, at greater intake levels, absorption decreases, and vice-versa) (Frost, 2012). Inuit also have normal serum calcium levels (though this is not always a good measure of calcium sufficiency, as serum calcium levels are highly regulated). Interestingly, Inuit children respond negatively to calcium supplementation despite their calcium-deficient diets, which could be related to more efficient intestinal calcium absorption and the predominance of the bb genotype for the vitamin D receptor (Sellers et al., 2003).

Side-Note. In an interesting 'self-experiment' Stefansson decided to test the idea that scurvy could be avoided if eating a traditional Inuit diet: "The fact that Eskimos were unaffected by the disease prompted Stefansson to condition his men to the native regimen before embarking on their explorations. Subsequently, in a celebrated experiment, he and his associate Karsten Andersen sustained themselves in good health under medical

supervision for a year with a diet of fresh meat and fat. Stefansson's appraisal of the ascorbic acid nutriture of the Eskimo has successfully withstood 40 years of critical evaluation, namely "...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" (Stefansson 1935-36). The Eskimo practice of eating their food in the raw, frozen, or lightly cooked state was a critical factor in preserving the small amounts of vitamin C necessary to prevent scurvy (less than 10 milligrams per day)" (Draper, 1977).

Inuit Metabolism

Overview of metabolism. I'm providing a brief overview of general metabolism; though, as mentioned in other locations throughout this summary, adaptation to the Arctic environment has resulted in the Inuit using primarily lipids and amino acids for metabolism; though, as explained later, this doesn't result in ketogenesis. Immediately after a meal, the body uses both glucose and amino acids from the diet to provide energy, in the form of glucose, to the brain and other glucose-dependent tissues (i.e. red blood cells). Additionally, non-glucose-dependent tissues (i.e. skeletal muscle) will use glucose for energy immediately following food intake, since glucose is readily available at this time. Any glucose consumed during a meal that isn't used by the brain and

other glucose-dependent tissues is taken up by skeletal muscle and adipose tissue. In the skeletal muscle, about half of this glucose is stored as glycogen and half is oxidized for energy. In the adipose tissue, the glucose is converted to be used as the backbone for triglycercides. About 50% of amino acids consumed during a meal are used to make glucose, while other amino acids are used for protein synthesis or are catabolized by the skeletal muscle or kidneys. Dietary fat is predominantly deposited in adipose tissue stores post-prandially. If the amount of dietary fat consumed exceeds the storage capacity of visceral adipose tissue depots and intramuscular triglyceride depots, the extra fat will typically be stored in the liver (this is NOT a good thing from a health perspective!). During fasting states (between meals), the body relies on endogenous sources of energy. The liver regulates blood glucose levels by breaking down glycogen into glucose. When this occurs, tissues that are not glucose-dependent switch to alternative fuels in order to preserve liver glycogen for glucose-dependent tissues. The non-glucose-dependent tissues oxidize fatty acids, either those stored in the adipocytes or in intra-muscular triglycerides, to obtain sufficient ATP.

In regards to ketosis, the body typically only enters ketosis during times of long-term starvation. During early starvation, the body uses amino acids for gluconeogenesis; however, long-term use of body

proteins during starvation can result in death, as proteins will eventually be taken from muscle tissues. Once proteins are taken from smooth muscle or cardiac muscle, death is the likely result. Therefore, in longer-term starvation, lipid metabolism adapts to create ketone bodies as an energy source for the brain in an attempt to spare body proteins. Therefore, in an attempt to protect life, the body transitions to a state of ketosis. As ketone body concentrations in the plasma rise, ketosis can occur, which results in the loss of sodium ions from the body and metabolic acidosis, which can lead to coma and death. Additionally, while the production of ketone bodies to fuel the brain does provide a short-term solution for sparing body protein, using ketone bodies for energy actually expends additional energy, resulting in a lower net energy yield from ketone bodies compared to typical beta-oxidation of fatty acids. Despite this pathway being energetically wasteful, the formation of ketone bodies has been preserved throughout evolution because the brain cannot metabolize fatty acids for energy (Stipanuk, 2006).

Metabolic adaptations to traditional Inuit diet. Despite the macronutrient composition of the traditional Inuit diet, characterized by high fat, moderate protein, and low carbohydrate intake, the Inuit diet has not been shown to be ketogenic, and studies demonstrate that the ratio of fatty-acid to glucose are below levels that would promote ketogenesis (Sinclair, 1953). The belief that the Inuit diet

may promote ketogenesis stemmed from the belief that Inuit eat high protein diets, when, they in fact eat high fat, moderate protein diets. In fact, the Inuit intentionally limit their intake of lean meat, giving excess lean meat to their dogs (Phinney, 2004). While data in general suggest the Inuit diet is not ketogenic, researchers believe there were "likely that there were times when the supply of protein was inadequate to meet the amino acid requirements for glucose synthesis as well as for protein synthesis" (Draper, 1977). In such situations, it is supposed that the Inuit may have experienced asymptomatic ketosis and ketonuria, but it is unknown whether or not the Inuit have adapted to these conditions (Draper, 1977). The Inuit appear to have adapted to the higher levels of gluconeogenesis required by their bodies (due to low carbohydrate intake) via increased liver size and high urine outputs accompanied by the consumption of large quantities of water (Draper, 1977). Greater water intake was due to a physiological feedback mechanism promoting greater water intake when urea levels are high to prevent urea from accumulating in the bloodstream (uremia) (Draper, 1977).

Inuit intolerances to sugars. The small amounts of sugars in traditional diets of Arctic natives has weakened their diversity of carbohydrate-utilizing enzymes and 63-100% of aboriginal populations in Greenland, Canada, and Alaska have primary hypolactasia (Kozlov et al.,

2005). Not surprisingly, there are no traditional Arctic dishes containing whole milk, likely due to its large quantity of lactose (Kozlov et al., 2005). Along with hypolactasia, some Greenland and Alaskan Eskimos have a novel racial-ethnic form of primary sucrase deficiency in which their intestines fail to digest sucrose, resulting in sucrose intolerance (Draper, 1977). The incidence of sucrose deficiency in Eskimos varies by location, with a rate of 10.5% in Greenland Eskimos, 2-3% in Wainwright, Alaska, and none among the Kasigluk or Nunapitchuk in southwest Alaska (Draper, 1977). These differences are likely due to variations in traditional diets related to geography, and sucrose deficiency is incredibly rare among Europeans (Kozlov et al., 2005). In contrast to lactose intolerance, which develops as lactase production declines after weaning, sucrose deficiency is present from birth (Draper, 1977). Trehalase deficiency is also rare in humans, except in the Greenlander Inuit, in which the incidence rate is 10-15% (Kohlmeier, 2003)(p.197). Inuit dislike of mushrooms may relate to trehalase deficiency, as mushrooms contain trehalose, and eating mushrooms would likely have caused a stomachache for those who were trehalase deficient (Kozlov et al., 2005).

Gut Microbiota

Recently, researchers have examined the Inuit gut microbiome in comparison to gut microbiome of

individuals consuming a Western diet (specifically, people from Montreal). Overall, the gut microbiomes of Montrealers and Inuit were indistinguishable and had similar microbial diversity. However, those Inuit who consumed diets more typical of a Western diet had greater amounts of *Prevotella*, similar to the amount found in Montrealers. This particular bacteria is associated with high-fiber diets and thus is less prevalent among Inuit eating a more traditional, low fiber Inuit diet. The Inuit consuming a traditional diet also had less diversity within the *Prevotella* genus, which researchers believe suggests that a low-fiber diet may select against *Prevotella* and reduce its diversity. Other bacteria, such as *F. prausnitzii,* was less prevalent in the Inuit, which is not surprising as this bacteria has been associated with citrus fruit consumption. *Lactobacillales,* the bacteria associated with dairy consumption, was also lower among the Inuit. Despite some small differences between the Inuit and Montrealers, overall, the Inuit gut microbiome is not different from that of Montrealers. This finding likely reflects the dietary transition Inuit are undergoing in which they are eating more Westernized diets and likely does not reflect the ancestral Inuit microbiome. An overall lack of genetic diversity in the Inuit microbiome is believed to be related to generations of Inuit consuming low-fiber, traditional diets (Girard, Tromas, Amyot, & Shapiro, 2017).

A follow-up study revealed that seasonal variations in the availability of specific traditional Inuit diets contributed to variations in the gut microbiome. They found that, when sampling across and entire year, diet explained 11% of variation in the gut microbiome for all participants, and accounted for 17% among the Inuit. There were no clear seasonal shifts in microbiomes of Montrealers or the Inuit; however, within-individual microbial diversity fluctuated more over time in the Inuit than the Montrealers, likely due to the greater variability and individualization of Inuit diets. The authors again concluded that greater Westernization of the Inuit diet likely accounts for less pronounced seasonal changes in the gut microbiome. (Dubois, Girard, Lapointe, & Shapiro, 2017).

Inuit Health

Stature. Data suggests that living in the harsh Arctic environment imposed selective pressures on the Inuit, resulted in genetic differences between the Inuit and other populations, some of which are related to height and nutrition. Specifically, the Inuit demonstrate allele-frequency differences in the fatty acid desaturases *FADS1, FADS2,* and *FADS3*, all of which are associated with diets high in PUFAs, and these differences likely compensate for higher dietary intake of EPA. These genetic mutations were found in almost 100% of the Inuit;

whereas, they are only present in 2% of Europeans and 15% of Han Chinese. These genetic variations in fatty acid desaturases affect height, likely due to effects of fatty acid composition and concentration on regulating growth hormones, such as insulin-like growth factor-1. These genes also affect weight. The respective effects on height and weight are 2 cm and 4 kg, respectively, with the Inuit being shorter than Europeans. Finally, these genes have a protective effect on cholesterol (lowering LDL), triglyceride levels, and insulin levels. Importantly, the effects of these mutations on height represent the strongest genetic effect ever found related to height (Fumagalli et al., 2015).

Lifespan. As of 1991, the life expectancy at birth for Inuit-inhabited areas was about 68 years, which was 10 years below the overall average in Canada. From 1991 to 2001, life expectancy for the Inuit-inhabited areas held constant at 68 years; however, the average in Canada rose by 2 years. Short-comings in Aboriginal death registrations made it unfeasible to specifically calculate life expectancy rates specific to the Inuit population, which is why a geographic-based approach was used to estimate life expectancy (Wilkins et al., 2008).

Disease risk. In the past 50 years, the Inuit have experienced a health transition related to rapid Westernization. One key characteristic of this transition is

an enormous decline in the prevalence of infectious diseases, particularly tuberculosis, which was one of the most common causes of death among the Inuit during the 19th and early 20th centuries. However, infectious disease rates are still higher than average among the Inuit populations. Rates of botulism poisoning (from *Clostridium botulinum*) are higher among the Inuit due to their traditional practice of fermenting meat (Shaffer, Wainwright, Middaugh, & Tauxe, 1990). Rates of *Trichinella* are also somewhat higher among the Inuit due to their greater consumption of game (Bjerregaard, Young, Dewailly, & Ebbesson, 2004; Proulx et al., 2002).

Overall, chronic disease risk has also increased among the Inuit. Generally, cancer rates are similar among the Inuit and their national counterparts (Nielsen, Storm, Gaudette, & Lanier, 1996); however, the Inuit have the world's highest rates of several specific cancers that are otherwise rare (Lanier & S.R., 1996). These include cancers of the nasopharynx, the salivary glands, and the esophagus (Lanier & S.R., 1996). Rates of these cancers are declining among the Inuit as they become more westernized, with concomitant increases in modern cancers, such as lung, breast, colon, and cervical cancer (Hildes & Schaefer, 1984). Diabetes prevalence has increased among the Inuit in the past several decades to the point that rates are now comparable to those observed in the general Canadian population (Egeland, Cao, &

Young, 2011). Increased diabetes prevalence is a common occurrence among native cultures undergoing rapid Westernization. Finally, cardiovascular disease mortality is higher among the Inuit than in Europeans and North Americans (Bjerregaard, Kue Young, & Hegele, 2003). Cerebrovascular disease mortality is higher among the Inuit; however, the Inuit due appear to have comparable levels of atherosclerosis to those of Europeans and North Americans. Inuit blood pressure is, on average, low in comparison to most European populations. Recent increases in chronic disease contrast with previous assumptions that the Inuit were protected from cardiovascular disease and diabetes. Previously, it was believed that a combination of genetics, high intake of marine mammals and fish, and large quantities of vigorous physical activity protected the Inuit from these diseases. This was likely the case; however, rapid changes in lifestyles, including dietary changes and increased rates of smoking, resulted in rapid increases in chronic disease risk. Pollution of traditional foods by man-made chemicals used in coal mining may also affect children's neuropsychological development and increase the Inuit susceptibility to infections and their immune status (Bjerregaard et al., 2004).

There may be genetic reasons why, historically, there has been a low prevalence of cardiovascular disease among the Inuit. Specifically, researchers found that the Inuit

have a significantly lower frequency of the MTHFR V677 allele than white populations. This allele is associated with the enzyme required for methylation of homocysteine and its presence is a genetic risk factor for cardiovascular disease, specifically when accompanied by a folate-deficient diet. This low V677 allele frequency in the Inuit could be related to their ancestry related to migration from Siberia, or it could be the result of selection pressures related to living in cold Canadian climates. This low frequency may also explain low prevalence of cardiovascular disease in Inuit populations (Hegele, Tully, Kue Young, & Connelly, 1997).

The most important cause of death among the Inuit until age 35 is injury. Injuries may account for 1/3rd of all deaths and include intentional injuries, such as suicide or homicide, and unintentional injuries or accidents (Young, Moffatt, & O'Neill, 1992). Alcohol in particular accounts for many injuries and for changes in the types of injuries the Inuit experience. Specifically, alcohol related motor vehicle accidents have increased in prevalence (Bjerregaard, 1990). Interpersonal violence is another major health concern in Inuit populations. Increased rates of interpersonal violence may be due to the stress of rapid social changes and to the inadequacy of traditional methods for resolving conflicts within their changing sociocultural environments. Finally, adolescent suicides have increased dramatically since the 1950s, which is a

similar pattern to other indigenous communities undergoing rapid Westernization. Suicides and suicide attempts also happen in clusters, with several suicide attempts associated with each completed suicide (Boothroyd, Kirmayer, Spreng, Malus, & Hodgins, 2001). The precise reasons for increased suicide rates are unclear, though they may be due to mental illness or peer pressure (Bjerregaard et al., 2004).

Nutrigenetic adaptations

As discussed under stature, the Inuit appear to have evolved to selectively express different alleles of the fatty acid desaturases *FADS1, FADS2,* and *FADS3*, all of which are associated with diets high in PUFAs. These differences were to compensate for greater consumption of EPA. The mutations in these genes downregulate the production of omega-3 and omega-6 PUFAs. These genetic variations in fatty acid desaturases have a protective effect on cholesterol, triglyceride, and insulin levels. Data from theses study provide some of the first evidence of human adaptations to specific diets and to physiological responses to diets. Such that, for the Inuit, it may be good for them to eat a very large quantity of omega-3 fatty acids, but this may not be the case for other human populations. "We think it is a quite old selection that may have helped humans adapt to the environment during the last Ice Age, but the selection is far stronger in

the Inuit than anywhere else," said Fumagalli. "It's fascinating that Greenlanders have a unique genetic makeup that lets them better use their traditional food sources" (University of California-Berkeley, 2015). Mutations found in the Inuit variant of the TBX15/WARS2 gene related to brown fat likely helped the Inuit adapt to living in cold environments by increasing their expression of brown fat, which generates heat (Molecular Biology and Evolution (Oxford University Press), 2016).

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