

## Ideas with Histories: Traditional Knowledge Evolves

Matthew J. Walsh,<sup>1,2</sup> Sean O’Neill,<sup>2,3</sup> Anna Marie Prentiss,<sup>4</sup> Rane Willerslev,<sup>5</sup> Felix Riede,<sup>2,6,7</sup> Peter D. Jordan<sup>8,9</sup>

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**ABSTRACT.** Anthropologists have long been fascinated by the strikingly similar adaptations of circumpolar cultures as well as their puzzling differences. These patterns of diversity have been mapped, studied, and interpreted from many perspectives and often at different social and spatiotemporal scales. While this work has generated vast archives of legacy data, it has also left behind a fragmented understanding of what underpins Arctic cultural diversity and change. We argue that it is time to engage with questions that highlight the roles of socio-environmental learning and cumulative cultural inheritance in shaping human adaptations to Arctic environs. We situate this in light of longue durée adaptations to environmental change. We examine five case studies that have used this framework to explore the genealogy of northern cultural traditions and show how social learning, cultural inheritance, and transmission processes are germane to understanding the generation and change in varied information systems (i.e., traditional knowledge). Specifically, a cultural evolutionary framework enables long-lens insights into human decision-making trajectories, with continued and prescient impacts in the rapidly changing Arctic. It is critical to improve understandings of traditional knowledge not as static cultural phenomena, but as dynamic lineages of information: ideas with histories. Improving knowledge of the dynamic and evolving character of inherited traditional knowledge in circumpolar human-environment interactions must be a research priority given the pressures of accelerating climate change on Indigenous communities and the social-ecological systems in which they exist in order to help buffer cultural systems against future adaptive challenges in the rapidly changing Arctic.

**Key words:** Arctic; circumpolar cultural diversity; traditional knowledge; social learning; cultural inheritance; cultural evolution; social-ecological systems; climate change

**RÉSUMÉ.** Depuis longtemps, les anthropologues sont fascinés par les adaptations similaires et les différences intrigantes des cultures circumpolaires. Ces tendances ont été cartographiées, étudiées et interprétées sous différents angles, souvent à des niveaux sociaux ou spatiotemporels différents. Même si ces études ont produit d’importantes quantités de données, celles-ci ne couvrent pas la totalité de la diversité culturelle de l’Arctique ainsi que les changements culturels qui s’y exercent. Nous soutenons que le moment est venu de considérer le rôle joué par l’apprentissage socioenvironnemental et l’héritage culturel cumulatif dans les adaptations humaines à l’environnement arctique. Pour ce faire, nous situons notre recherche dans l’adaptation aux changements environnementaux de longue durée. Ici, nous présentons cinq études de cas qui utilisent cette même porte d’entrée, soit des études sur la transmission culturelle, en examinant la généalogie des traditions du Nord et en montrant que l’apprentissage social, l’héritage culturel et les processus de transmission sont liés à la compréhension de la création et du changement de systèmes d’information variés (c’est-à-dire les connaissances traditionnelles). En particulier, une étude de transmission culturelle nous amène à la formation de perceptions clés de longue durée au sujet du processus humain de prise de décisions, en tenant compte des impacts continus et actuels dans l’environnement arctique en pleine évolution. Il est essentiel d’améliorer notre compréhension des connaissances traditionnelles, non pas en tant que phénomènes culturels statiques, mais en tant que lignages d’information : des idées qui ont des histoires. L’amélioration de la compréhension de la dynamique et du caractère changeant des connaissances traditionnelles doit figurer parmi nos priorités de recherche, surtout lorsqu’elles concernent des interactions anthro-environnementales dans des régions comme l’Arctique où les changements environnementaux rapides et leurs effets sur les communautés autochtones ainsi que les systèmes socioécologiques dans

<sup>1</sup> Corresponding author: Modern History and World Cultures Section, The National Museum of Denmark, Ny Vestergade 10 Prinsens Palæ, DK-1471 Copenhagen C, Denmark; [matthew.walsh@natmus.dk](mailto:matthew.walsh@natmus.dk)

<sup>2</sup> Arctic Research Center, Aarhus University, C.F. Møllers Allé 8, bldg. 1110, DK-8000 Aarhus C, Denmark

<sup>3</sup> Museum of Cultural History, University of Oslo, Department of Ethnography, Numismatics, Classical Archaeology and University History, Oslo, Norway

<sup>4</sup> Department of Anthropology, The University of Montana, Missoula, Montana 59812, USA

<sup>5</sup> The National Museum of Denmark, Ny Vestergade 10 Prinsens Palæ, DK-1471 Copenhagen K, Denmark

<sup>6</sup> Department of Archaeology and Heritage Studies, Aarhus University Moesgård, Moesgård Allé 20, 8270 Højbjerg, Denmark

<sup>7</sup> BIOCHANGE: Center for Biodiversity Dynamics in a Changing World, Aarhus University, Ny Munkegade 114-116, 8000 Aarhus C, Denmark

<sup>8</sup> Department of Archaeology and Ancient History, Lund University, Box 192, 221 00 Lund, Sweden

<sup>9</sup> Global Station for Indigenous Studies and Cultural Diversity, Hokkaido University, Kita 21, Nishi 11, Kita-ku, Sapporo 001-0021, Japan

lesquels ils évoluent exercent encore plus de pression. Ce n'est qu'avec ces types de connaissances que nous pouvons espérer planifier et, par le fait même, protéger les systèmes culturels des défis d'adaptation auxquels l'Arctique en évolution rapide fera face à l'avenir.

Mots clés : Arctique; diversité culturelle circumpolaire; connaissances traditionnelles; apprentissage social; héritage culturel; évolution culturelle; systèmes socioécologiques; changements climatiques

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Археологов и этнографов давно интересуют удивительные параллели и, вместе с тем, загадочные различия в адаптационных стратегиях циркумполярных культур. Модели культурного разнообразия изучались с различных точек зрения и часто в разных социальных, пространственных и хронологических контекстах. Эти исследования привели к созданию обширной базы культурно-исторических источников, однако они позволили сформировать лишь фрагментарное понимание причин и условий разнообразия и трансформаций культур Арктики. В результате, многие поведенческие режимы и навыки северных народов определяются сегодня с позиции «традиционного знания». В этой статье мы доказываем, что необходим новый и более гибкий подход к объяснению этих культурных явлений. В частности, важно тщательно проанализировать роль социального обучения и передачи от поколения к поколению культурной информации в активном формировании традиций и адаптационных моделей арктического мира. Наше исследование рассматривает пять сюжетов, концентрирующих внимание на факторе социального обучения как важном условии понимания исторических корней и эволюционных изменений в различных традиционных практиках Севера. Установлено, что перспективным направлением является изучение временной динамики «траекторий принятия решений». Это позволяет выявлять как исторически сложившиеся, так и динамичные черты в традициях северных культур. Мы делаем вывод, что понимание «традиционного знания» не как статичного культурного феномена, но как подвижного вектора передачи информации в процессе смены поколений, имеет принципиальное значение. Развитие наших представлений о динамичном характере унаследованных традиций также важно для разработки оптимальных адаптационных стратегий будущего. Дальнейшие исследования в этом направлении особенно актуальны в условиях возрастающего влияния изменений климата на среду обитания коренных народов Севера.

Ключевые слова: Арктика, циркумполярное культурное разнообразие, традиционные знания, социальное обучение, наследство, культурная эволюция, социально-экологические системы, изменение климата

## INTRODUCTION

The circumpolar region is changing fast. The Arctic is currently experiencing accelerating processes of human-induced rapid environmental change (HIREC). Climatic warming transforms local ecosystems and impacts heavily on Arctic Indigenous communities that rely on those ecosystems for traditional lifeways. Concurrently, Arctic archaeological heritage is at dire risk of climate-driven degradation (Vaughn et al., 2013; Larsen et al., 2014; SAA, 2016; Hollesen et al., 2015, 2016; McGovern, 2018; Desjardins and Jordan, 2019; Fenger-Nielsen et al., 2020). Understanding the deeper history of circumpolar cultural traditions and how they have changed over time has never been more urgent nor more relevant. How cultural inheritance—and especially contrasting sets of cultural traditions—evolved in unstable, non-equilibrium ecosystems remains little understood. There is a need to better understand how cultural traditions evolved in dynamic ecological contexts in order to help anticipate and plan for future scenarios in the changing North. To date, traditional ecological knowledge (TEK), traditional knowledge (TK), or Indigenous knowledge are widely discussed (for a review see Dahl and Tejsner, 2020), but we believe often in too static and ahistorical ways. We

suggest that comparative approaches aimed at exploring deeper historical trajectories can provide dynamic insights into how northern cultural traditions changed over time, and how they may have led to cultural inertia or time lags, where canalized lifeways became no longer flexibly adaptive to environmental change, leading to maladaptation in diverse settings (Laland and Brown, 2006).

TK is an oft highlighted resource for adaptive solutions and future resilience in the Arctic and beyond (see Berkes et al., 1995, 2000; Berkes, 1999; Nakashima et al., 2012; Pearson et al., 2021; [in general], Desjardins et al., 2020a [more specifically]). Paradoxically, ancestral traditions and knowledge tend often to be considered as fixed. It is well established that accumulated traditional knowledge is a valuable and important source of cultural resilience. However, it is often inappropriately approached as a static phenomenon. We suggest that this view may hinder or delay future solutions and effective responses drawn from TK. We take the stance that TK is no singular set of ideas in any case, but rather mutable ways of understanding lived experience; TK represents ideas with histories. We offer a solution to this dilemma of stasis that recognizes the complex underpinnings of what we refer to as ancestral traditions, thus evoking issues of inheritance, agency, and situational plasticity. We argue that there is substantial evidence that

TK has evolved over time via cultural inheritance processes. In thinking about TK as a static ahistorical corpus of information, we do a disservice to current and future generations by not learning from examples drawn from the near and remote past regarding how TK was developed, transmitted, and acted upon over long periods of time.

Here we look at examples from the archaeological and ethnological records to support this perspective. We review five case studies that illustrate the processes by which knowledge evolved and varied within diverse Arctic and sub-Arctic contexts (c.f. Burke et al., 2021). Then, we draw from these discussions to consider the wider relevance of a perspective on TK that acknowledges its underpinnings, its status as reservoir of possible variation, and its potential to provide guidance in uncertain times.

Further, we propose that it is time to revisit circumpolar cultural traditions from deeper historical perspectives and view them as dynamic, human-oriented, and longer-term adaptations that have developed by way of processes of descent with modification (c.f., Jordan, 2015; Brewer and Riede, 2018; Jones et al., 2021). A combined focus on socio-environmental learning, cultural inheritance, and comparative perspectives has the potential to provide an integrative framework to what has become a fragmented field, but whose importance looms ever clearer in the current unfolding of HIREC. The approach sketched out here offers an integrative and diachronic framework for understanding traditional knowledge as a source of past, present, and future cultural variability, adaptability, and potential resilience. This is a pressing issue due to the growing realization of the speed and severity of ongoing HIREC. This emergency demands new efforts in mitigation and scenario planning to safeguard the best prospects for futures across the region, both for archaeological and contemporary cultural heritage, as well as for ecological sustainability, moving forward.

At a time when interest in TK is set to play an increasing role in circumpolar research (e.g., Dahl and Tejsner, 2020), we argue that some challenges can in part be addressed by revisiting earlier perspectives on what drives circumpolar cultural diversity and updating the concept of cultural traditions and knowledge by situating them in dynamic long-term perspectives (cf. Rockman, 2012; Riede et al., 2018). An ideal framework for this proposition is provided by a focus on cultural evolution in relation to socio-environmental learning, cultural inheritance, and the genealogies of specific cultural traditions.

## RETHINKING CIRCUMPOLAR THINKING

The Greater Circumpolar Zone (Fig. 1) is a complex mosaic of maritime, riverine, and terrestrial ecosystems in the northernmost reaches of the Northern Hemisphere. It is also home to Indigenous societies with remarkable levels of diversity that also share several key commonalities generally recognized as variants of cultural adaptations

to life in the unique, challenging conditions of the circumpolar. How these cultural patterns emerged, persisted, and changed over time remains a unifying focus for researchers, Indigenous communities, and increasingly for planners and policy makers seeking to develop future infrastructure and mitigation efforts as the Arctic moves into an era of intensive climate-driven transformation and increased global concatenation. But much of this new work currently lacks a coherent integrative framework—an updated “Circumpolar Thinking” agenda—thus hindering attempts at deeper interdisciplinary understandings and wider transdisciplinary engagement.

Early studies into circumpolar adaptations and cultural change encouraged a multidisciplinary approach; however, they also tended to highlight cultural uniformity over large areas (e.g., Royal Geographic Society, 1875). Climate and environment were argued to directly drive the most important migrations and contractions of human and animal populations, as well as seasonal fluctuations in floras, at times with unsavoury connotations (Livingstone, 1991). Growing interest in the role of ecology and climate change has since highlighted the pivotal roles of coastal and riverine ecosystems as sources of surplus production that can be seen to have supported larger populations and greater levels of cultural elaboration. In the last 20 years, this overarching human-environmental agenda has fragmented into more local and regional research perspectives and has benefitted from engagement with Indigenous communities.

Until the late 19th century, academic understandings of northern societies were based primarily on the limited accounts of travellers and explorers, supplemented by a few expedition reports. European visitors to the Arctic were fascinated by the capacity for humans to survive in such frigid conditions. Meanwhile, armchair anthropologists read these accounts and speculated freely about the shared origins and diverse beliefs, customs, and material culture of these remote high-latitude societies. Some proposed distant connections between the ancient cultures of the European Palaeolithic and the still “frozen” societies of the contemporary Arctic (Fitzhugh, 2010:88-91). Gradually, understandings started to focus on a chain of remote and widely scattered Arctic communities that exhibited close similarities in technology, culture, and language, which triggered the search for the origins of the “Eskimo” peoples, who were initially thought to have developed somewhere in the North American Arctic.

By the early 20th century, efforts to resolve this so-called “Eskimo Problem” (the quandary surrounding the origins of Indigenous societies in the North American Arctic) had galvanized the emerging field of circumpolar anthropology. The central challenge was explaining the existence of a well-defined Arctic culture that shared a similar technology and economy and spoke a chain of closely related languages and dialects extending from Chukotka to Greenland (Fortescue, 1998; Fitzhugh, 2010:88). Other intellectual developments also played a role. These included the professionalization of anthropology and the promotion of

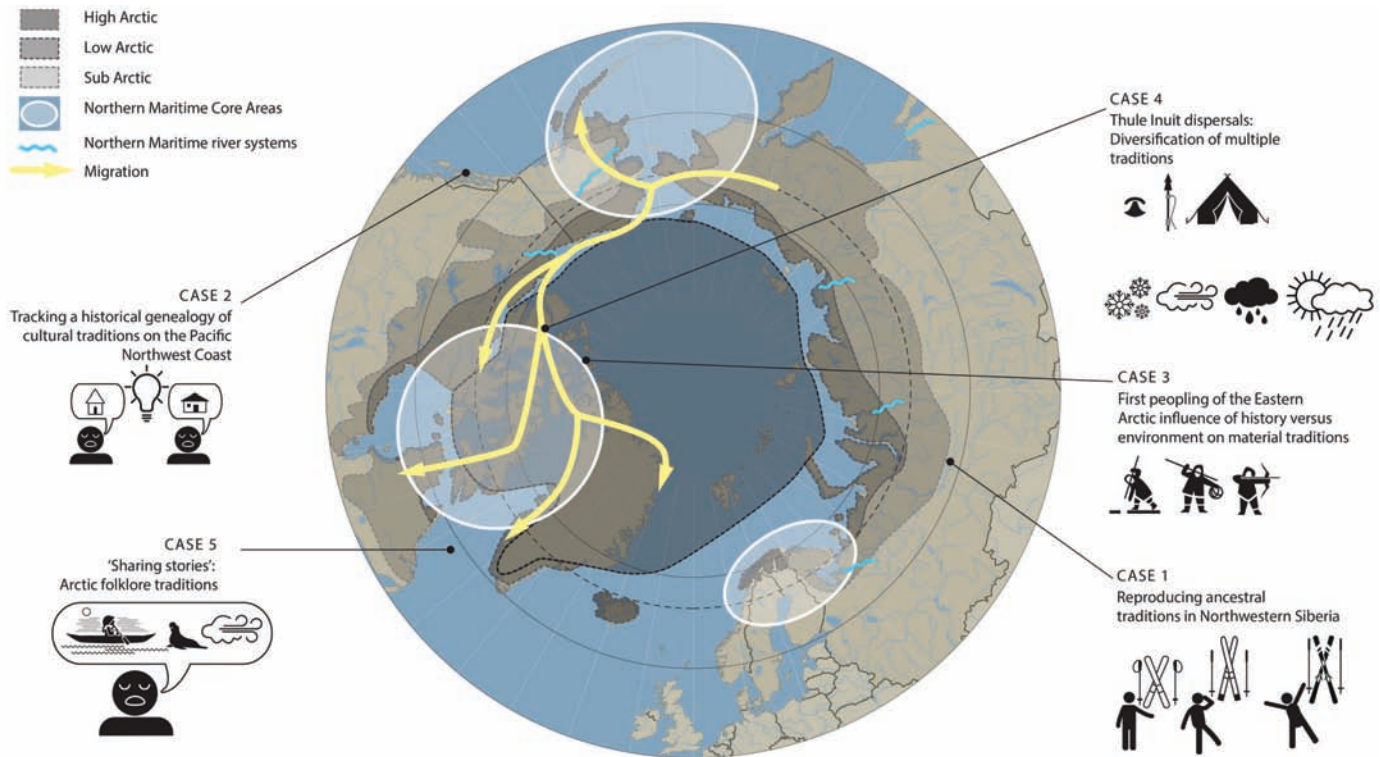


FIG. 1. The Greater Circumpolar Zone showing the locations of the case studies discussed in the text. Waldemar Bogoras likened the Arctic Ocean to the Mediterranean Sea. Intense interactions along these seasonally frozen coastlines gave rise to a “special northern circumpolar culture,” which was uniform over large areas and largely isolated from southern cultural influences (Bogoras, 1924:226–227).

long-term field studies (e.g., Boas, 1901, 1907, 1964; Hatt, 1914; Stefansson, 1914; Bogoras, 1924, 1929; Jochelson, 1928, and the numerous contributions made by members of the Fifth Thule and Jesup North Pacific expeditions, among others). Ultimately, these studies led anthropologist Waldemar Bogoras (1929:579) to present the Arctic as a vast but rather self-contained interaction zone, which he rightly concluded offered “an excellent field for the comparative study of a culture, perhaps unique in the world.” Not long after, Gutorm Gjessing’s *Circumpolar Stone Age* (1944) was projecting this framework farther back in time, highlighting archaeologically a common adaptive and technological complex across the Arctic. While ecological diversity was ever present in the earliest studies, it was bridged by cultural commonalities and the assumption that environmental conditions were relatively fixed and that Arctic cultures were simply handsomely adapted to their frigid, unchanging conditions (e.g., Friesen and Mason, 2016:9).

#### *Chronology, Ecology, and Maritime Core Areas*

A boom in Arctic archaeological fieldwork after WWII combined with radiocarbon dating led to a growing appreciation that Arctic climates and environments were more dynamic than previously thought. Growing interest in Julian Steward’s (1955) cultural ecology and eventually in the new processual archaeology (e.g., Binford, 1962) shifted the focus to understanding adaptive dynamics within more regional sequences. For the Arctic, climate and environment

were regarded as the primary and relatively direct drivers of cultural change. As climate warmed, glacial ice retreated and tundras bloomed; animal species expanded and human hunters followed. When temperatures cooled, this process reversed (McGhee, 1969–70). Hence, major cultural developments were explained as direct human responses to major environmental shifts (McGhee, 1969–70; Friesen and Mason, 2016:9; Desjardins and Jordan, 2019). From this environmentally deterministic perspective, human populations were trapped in an adaptive dilemma: those populations able to innovate could quickly exploit new conditions, whereas those unable to adjust quickly enough were replaced or died out.

These combined developments, along with declining academic contacts during the Cold War, steadily eroded interest in the original circumpolar comparative frameworks. They were replaced by new concepts that maintained certain comparative dimensions but highlighted the ecological and adaptive foundations of northern cultures, eventually culminating in the concept of “Northern Maritime Core Areas” (Fig. 1; see Fitzhugh, 2010:99–100). This concept illustrates that northern marine ecosystems have complex, multitiered food webs that are relatively stable and hypothetically predictable; interior ecologies are far less productive, having fewer species and simpler food webs. As such, humans have tended to focus on coastal and riverine ecosystems as these are more productive and ecologically stable. Over time, the supposed stability of water-oriented strategies has allowed

for more complex levels of cultural elaboration within those areas (e.g., Scaggs et al., 2021). Overall, this framework replaced the idea of a single unbroken chain of circumpolar cultures with a series of core areas that saw independent developments with changing interactions (or migrations) between them (Fitzhugh, 2010). It has become clear that marine and terrestrial ecosystems responded differently as Arctic climates fluctuated, leading to cultural and biotic expansions and contractions (Fitzhugh, 1972:167–197, 1977, 2010). In short, the general model was accurate but far more complex than previously thought.

### *Recent Interdisciplinary Developments and Challenges*

The emergence of a complicated picture of circumpolar diversity has left contemporary scholarship within this field increasingly fragmented. In addition, the focus, priorities, explanatory frameworks, and roles of stakeholders and local communities are actively expanding, albeit often in divergent directions. However, it is clear that driving forces of contemporary research hinge around 1) understanding and contending with HIREC, and 2) subsequently working towards resilience studies that attempt to address issues of fragility, resilience, and vulnerability of both environments and cultures in changing Arctic settings. We recognize the increasing confluence between climate change studies and TK, but an appropriate theoretical framework that can combine both aspects as chronologically structured has not yet emerged. Both climate and culture have correlative temporal dimensions that need to be better understood in order to make any sort of useful predictions or prognoses. Several key developments in circumpolar social and environmental sciences research that can help forge such a framework include higher-resolution chronological, cultural, and palaeoecological frameworks; the integration of new methods and data-oriented approaches; a focus on Arctic community engagement and TK; the rise of resilience/sustainability studies; and the use of transdisciplinary planning and mitigation efforts.

Combined efforts are starting to show that both warming and cooling trends can increase various species' population numbers and may have positive impacts on Arctic cultures (Desjardins and Jordan, 2019), even while Arctic ecosystems are inherently unstable and never reach equilibrium (Normand et al., 2013; Pellissier et al., 2016). There have been major regional shifts in climate and environment at a range of scales and intensities (Finkelstein, 2016). Many of these changes (e.g., the periodic expansion and persistence of sea ice; de Vernal, 2017; Szpak et al., 2019) likely had immediate and recognizable effects on past societies. Finally, it is clear that cultural responses to climate change are more complex, delayed, and variable than previously predicted (Friesen et al., 2020).

Research in the Arctic is benefitting from major advances in new analytical methods and integrative data-driven studies. This research includes the genetic history (DNA and aDNA) of both humans (e.g., Raghavan et al.,

2014) and the key species that they have relied on and interacted with (e.g., Brown et al., 2013; Ameen et al., 2019). Ever more robust data-driven reconstructions of population histories and human impacts continue to emerge.

Earlier research bypassed the needs of local communities. Despite close personal ties between many iconic Arctic researchers with their informants and communities, much of the earliest work remained firmly entrenched in the colonial asymmetries of their times. This previous lack of involvement has been especially true in the period of processual and large-scale adaptive approaches (Lyons, 2016). A new focus on community archaeology and Indigenous perspectives highlights the need for research to be societally relevant and to involve co-creation of knowledge and ideas with future planning solutions. Local Arctic peoples are aware of and understand well the movements of animals, weather signs, and cycles. They have deep, penetrating knowledge of their lands and resources that should not be ignored or downplayed. However, change is accelerating, and contemporary Indigenous observers describe current events with expressions along the lines of “we haven't seen these weathers before,” “the earth is faster now” (Krupnik and Jolly, 2002), and “the wind is stronger now” (Tejsner, 2019), which hint at increasing mismatches between TK and changing contemporary conditions.

The Arctic's diverse environments and Indigenous communities now face an impending tipping point, which is leading to resurgent interest in historical ecology, environmental and technological adaptations, and deeper knowledge of cultural traditions. Arctic resilience studies have emerged to address this gap in knowledge and reflects the growing appreciation of the pace and severity of modern Arctic climate change, as well as the profound existential challenges that those changes pose to Arctic Indigenous communities (e.g., Tejsner and Veldhuis, 2018; Dahl and Tejsner, 2020). These concerns have begun to produce a new generation of explicitly comparative circumpolar ethnological studies that use the concept of resilience to explore the potential sustainability and fragility of coupled social-ecological systems in different parts of the circumpolar North (AC, 2016). However, these case studies tend to have limited historical depth (c. 100–200 years) and rely on a restricted range of contemporary (or very recent) cultural and ecological baselines for understanding longer-term capacities for change (Desjardins et al., 2020a, b; but see also Barrios, 2016; Brewer and Riede, 2018). Although TK is discussed as a potential source of useful ideas for future adaptability, this body of praxis is presented in relatively static, timeless and even mystical terms; there remains a fundamental lack of understanding about how human decision-making processes and modifications actually operate under climatic pressures over multigenerational timescales. This is especially relevant when attempting to study the speed of adaptive change versus the role of behavioural inertia, which could lead to cultural maladaptation in response to changing conditions (Brewer and Riede, 2018). We should

also acknowledge that the systematic implementation of residential boarding school systems across North America and Russia during the 20th century effectively severed the chains of transmission between old and young generations. These school systems displaced Indigenous children out of traditional learning and knowledge spheres, thus disrupting generations of accumulated TK. The scope of this historical contingency is only just being fully realized. This disruption had significant and as yet considerably unexplored consequences for cultural transmission across the circumpolar region and beyond.

The goal of Arctic sustainability science is the identification of the various pathways that particular Arctic social-ecological systems may eventually take. The aim is to generate understanding and insight into how those systems may be steered into more sustainable and socially and environmentally positive directions. Identifying pathways and appropriate responses to HIREC is extremely difficult. But one key contribution can be made by simulation studies and (participatory) scenario planning exercises (i.e., that closely involve engagement with local communities and other stakeholders). Again, these rely on a restricted range of recent and potentially problematic cultural and ecological baselines that tend to see TK in ahistorical terms. More generally, these efforts often look at change in the entire social-ecological system. Less effort is directed at understanding the role of separate cultural or technological traditions over long time scales, which means that there remains a lack of knowledge on how specific regional and temporal cultural traditions (such as changes in subsistence technology or mobility patterns and within them TEK and TK in general) have evolved over multiple generations. As a consequence, the field lacks a proper integrative framework (c.f., Brooks et al., 2018).

#### *Emerging Opportunities: Building Transdisciplinary Insights*

Contemporary circumpolar research remains fragmented not just along the fault lines among the natural sciences, social sciences, and humanities, but in terms of how to generate holistic understandings of past developments and future prospects. This fragmentation works against integrated efforts not just within multi- or interdisciplinary research but also in transdisciplinary dialogues with local communities, planners, policy makers, and the global public at large, including the scientific community. While scholars like Bogoras and Gjessing (among many others) played a foundational role in establishing early theoretical frameworks for circumpolar comparison, we are confronted today by a more complicated situation than they likely imagined. Even so, their adaptive and comparative perspectives remain latently useful, but must be re-imagined into the contemporary world of HIREC—a world in which TK is not frozen in a temporal black box,

but framed as a dynamic set critical to cultural innovation, adaptation, and identity.

As Bogoras (1929:579) suggested nearly a century ago, the circumpolar does offer close to ideal natural experimental conditions to understand how humans make decisions and maintain traditions in dynamic environmental settings. The region has a history of small populations, tight survival margins, and high levels of linguistic and cultural diversity coupled with varying levels of ecosystem variability and change in distinct coastal, inland, and riverine biomes. Moreover, there exist large ethnological datasets that span all the major geographic zones and extend from the ethnographic present through to early prehistory. We posit that a potential contribution to solutions exists if we start to reengage with the concept of a “circumpolar cultural tradition,” but with the realization (in contrast to Bogoras and Gjessing) that this is not a single underlying phenomenon, but a collective body of information that has been and is sustained and shared locally by individuals and communities in specific environments and is passed from one generation to the next in ways that can be observed or modelled. In other words, those socio-technological traditions are evolved cultural-environmental systems. Thus, cultural transmission studies using phylogenetics can offer solutions to the vexing problems of shifting cultural diversity and adaptation in the Arctic. Indeed, the circumpolar offers socio-temporal pockets from which to investigate the evolution of human-environment adaptive behaviours and their consequences in the longer term. The focus that cultural evolutionary modelling can offer on human agency may provide valuable information on, for example, cross-generational decision-making processes, cultural inertia, or technological responses (or failures to respond) to changing conditions.

A comparative interpretive framework enables us to align some of the major themes in circumpolar archaeology and anthropology with new and emerging approaches in the study of social learning and cultural inheritance (Brewer et al., 2017). This framework starts by conceptualizing culture as a system of information transmission, where knowledge, know-how, and practices are passed on in the form of social traditions that leave historical traces (Matthews et al., 2011; Jordan, 2015). Within this system, units of inherited information of differing types and scales (e.g., from ideas to material objects) can be identified (Weingart et al., 1997), and their dynamics within the cultural system as a whole can be modelled and reconstructed phylogenetically (Boyd et al., 1997; Atkinson and Gray, 2005; Mace and Holden, 2005; Collard and Shennan, 2008; O’Brien, 2008; Gray et al., 2010; Lycett, 2015). Evolutionary approaches can be rigorous, integrative, and coherent, and operate on interlocking scales (see below and e.g., Boyd and Richerson, 1985; O’Brien, 1996, 2008; O’Brien and Lyman, 2000; Shennan, 2002, 2009; Mace et al., 2005; Lipo et al., 2006; Jordan, 2015; Prentiss, 2019).

SOCIO-ENVIRONMENTAL LEARNING,  
CULTURAL INHERITANCE,  
AND ENVIRONMENTAL ADAPTATION

Although humans can acquire new knowledge through direct trial-and-error learning, they tend to acquire most of their cultural information, skills, and knowledge by learning from and copying others (see, e.g., Case 1) within existing cultural systems or “niches” (sensu Laland and O’Brien, 2011; e.g., Cazzolla Gatti et al., 2020). As a consequence, different kinds of cultural information are passed on via social learning. In turn, specific behaviours and recipes for action persist in the form of a given social tradition. People decide what to copy, retain, modify, or reject, which means that large bodies of cultural information can build up from one generation to the next, leading to heritable continuity in cultural information (c.f. Tehrani and Collard, 2009). Therefore, it is possible to model the history and genealogy of particular traditions ranging from, for example, languages (Fortescue, 1998), to ways of making harpoons (Mason, 2009), to millennium-long housebuilding traditions (Jordan and O’Neill, 2010), to strategies of resource and landscape use (Prentiss et al., 2015, 2018) and beyond (e.g., Tehrani, 2013; Ross and Atkinson, 2016). Each of these are cultural phenomena among high northern latitude societies that have been fruitfully explored using comparative methods in evolutionary frameworks.

Our second point of departure is that all this learning, practice, modification, and transmission takes place in a particular environmental and ecological setting. Cultural reproduction is, in turn, embedded in and structured by tightly coupled social-ecological systems (AC, 2016). Cumulative culture is important in all regions. Yet it is imperative in harsh environments because it offers knowledge, skills, and the capacity to make vital technologies that support survival in quite extreme conditions. With high environmental risks, there is a premium on efficient social learning and high-fidelity transmission (Barrett et al., 2019), because no single person could possibly figure out an adequate suite of recipes for action from scratch on their own in their own lifetime. As a result, communities rely to some extent on the reproduction of valuable ancestral traditions. But against this backdrop, every generation has always made decisions about what to keep, modify, or abandon. Individuals experiment and discover novel innovations, such as the development of more effective toggling harpoons for breathing-hole sealing (Mason, 2009). If climatic and environmental conditions shift, then new versions may end up working better than older ones, or vice versa. Yet in most cases, adjusting to new environments takes time, because many optimal solutions may not be initially self-evident.

*Unstable Arctic Environments and Adaptive Cultural Responses*

Viewed in an ecological context, social learning allows new and potentially innovative and more adaptive behaviours or technologies to spread rapidly across generations. However, because cultural inheritance tends to lead to heritable continuity, if a force such as climate or environmental change is rapid enough or if certain behaviours become too locked in to individual- or group-level behaviours, then this cultural inertia (persistence of a cultural trait regardless of its advantage) can render the cultural tradition in question increasingly at odds with the new realities being faced. This inertia may lead to a trait becoming maladaptive. Rather than being inherently beneficial, such adaptive lags may mean that older traditions can eventually widen the mismatch between social learning and the acquisition of more adaptive behaviours (Laland and Brown, 2006). Importantly, different pathways of cultural transmission and social learning strategies can serve to help or hinder effective responses. Strategies hindering effective responses could be a distinct problem for small-scale groups seeking to survive within the non-equilibrium characteristics of Arctic ecosystems. Today, these challenges are deepening given the accelerating pace of modern climate change (see, e.g., Krupnik and Crowell, 2020 and works therein). Social learning in environmental context is key towards generating and maintaining adaptive traditions in situ, but their processes must not remain static under changing conditions. Learning must be dynamic, and it takes time. The increasingly perilous challenge of a tipping point in climate change is what Taleb (2007:15–16) has characterized as a “Black Swan”—a development that changes everything so radically and rapidly, that a new paradigm or form of existence emerges. But this undoubtedly will not have been the first Black Swan faced by high latitude groups. It is well worth examining more closely what the history of cultural adaptations in the Arctic can teach us.

*Socio-Environmental Learning and Cultural Lineages: Mechanisms and Methods*

Cultural adaptations are passed on through social learning. Researchers identify two contrasting kinds of learning: (1) trial-and-error (environmental) learning, which would involve an individual going out into an Arctic landscape and learning alone how to acquire resources, make clothing, build shelter, source fuel, and make fire; and (2) social learning, which involves learning all these skills from others via a process of cultural transmission or inheritance. In many small-scale societies, much of this early learning is in the form of vertical transmission, with parents investing time and effort to train their biological offspring (Mesoudi, 2007). Copying and especially imitation is uniquely developed in *Homo sapiens* (Tehrani and Riede, 2008; Csibra and Gergely, 2011; Jordan, 2015), to the

point that overimitation is common (Flynn, 2008; Nielsen and Tomaselli, 2010; Lyons et al., 2011). This capacity for high-fidelity copying and reproduction of often arbitrary combinations of traits within particular traditions is what maintains the corpus of cumulative culture that humans can tap into for environmental knowledge, technological skills or other practices (Beheim and Bell, 2011). In many ways, vertical transmission is akin to genetic inheritance, but this direct analogy is limited because humans can and do also copy from other members of other generations (oblique transmission), members of their own generation, or even from other groups (horizontal transmission).

Building on bodily heuristics (Kaaronen et al., 2021, 2023) and evolved social learning propensities (Laland, 2004), cultural inheritance often involves one-to-one learning, but also many-to-one (e.g., an older generation and the wider community enforce particular norms), or one-to-many (e.g., a teacher in a classroom or an elder passes on knowledge to a group of younger initiates) (Hoppit and Laland, 2013; Creanza et al., 2017). These various pathways make cultural transmission dynamic enough, but it gets even more complicated because people can actively choose what or whom to copy. They may also undertake some trial-and-error experimentation to see if they can improve the variants that they already have at their disposal. For example, a young hunter may acquire a particular paddle-making style from his father, but then realize through personal experience that another style works better. He then teaches this technique to his own son. In many cases, it is very difficult to know what works best, so people often copy what leaders or prestigious individuals do or simply switch to what the majority of their peers are doing (Richerson and Boyd, 2005:58–98). In other cases, important skills or knowledge can be lost or forgotten by accident, especially in small and isolated populations where the sudden accidental death of an adult can rob the community of potentially useful skills or cultural knowledge.

Starting with foundational studies that drew explicit positive and negative analogies between cultural and genetic inheritance (Cavalli-Sforza and Feldman, 1981; Boyd and Richerson, 1985), cultural transmission theory has now defined and documented a wide range of processes, biases, and other decision-making influences that can have enormous and often unpredictable impacts on what cultural traits are passed on from one generation to the next (O’Neill, 2013; Jordan, 2015; Riede et al., 2019). These processes can be studied in living ethnographic settings to examine how the interplay of different factors works in real situations. They can also be modelled and simulated, given the explicit definition of variables and how they interact over multiple generations or different environmental conditions. Despite all of this, some form of heritable continuity in cultural traditions tends to be observed, which suggests that social learning remains the core process in intergenerational cultural reproduction.

As mentioned above, in terms of environmental adaptation, this continuity can be a double-edged sword.

Rapid and more effective technologies or behaviours can spread readily even within a single generation. At the same time, the heritable continuity that is central to many cultural traditions means that older and potentially maladaptive traits can persist even while new environmental conditions are rendering them increasingly vestigial or even destructive (though this may not be apparent for some time). These processes are poorly understood, especially over longer multigenerational time scales, which leaves the implicit (and potentially spurious) assumption that Arctic social learning is inherently adaptive without effective critique. Yet, there are ways to track such phenomena (see below).

## LOOKING TO THE NORTH: FIVE CASE STUDIES

So how can such long-term and complex historical processes be effectively investigated in terms of TK, cultural inheritance, and evolutionary process? Below, we review five case studies that illustrate the point that cultural evolution methodologies can provide valuable insights for better understanding TK through time and across diverse and changing environments. Our goal is to show that cultural inheritance is always the result of a complex evolutionary process and thus not the persistence of a singular unchanging suite of universal wisdom. We feel that it is important to clearly make the case that Indigenous peoples and their varied TK are not and were not static entities exempt from cultural change. Rather, like all societies, they have diverse and dynamic histories of adaptation, and it is a disservice to all Indigenous peoples to not recognize those histories in the highest resolution possible (e.g., Wolf, 1982).

Indeed, the circumpolar North abounds with rich ethnographic settings. Many northern communities maintain traditional crafting, folklore, and language as part of their Indigenous identities, many of which have been inherited directly from parents and ancestors and are still being maintained, modified, and passed on to the next generation. The case studies given below provide just a few examples of the cultural traditions that can be explored using comparative methodologies.

### *Case 1: Reproducing Ancestral Traditions in Northwestern Siberia*

Some of the most detailed studies of the transmission of circumpolar craft traditions have been conducted in the taiga forests of Northwest Siberia, among communities of Eastern Khanty. These have focused on documenting specific kinds of artifacts in terms of their constituent traits, among communities who have been living on the land with the same social structures for generations and centuries (Jordan, 2015:110–217). Such living contexts offer rich scope for studying social learning and cultural inheritance in action.



Jordan's (2015) study explores how the intersection of seasonal mobility, kinship and intermarriage, and residence patterns provide a unique context to social learning, enculturation, and the reproduction of diverse craft traditions. Here we highlight four main insights of this research. First, vertical parent-to-child inheritance plays a major role in early life, enabling males and females to master a wide range of generic craft skills (i.e., TK). But by adolescence and extending into adulthood, individuals experiment, innovate, and adjust those inherited traditions; showing that TK is not static, but rather a constant potential arena for innovation.

Second, within this dynamic setting, some traditions, including ski-making (Fig. 2), were propagated as coherent lineages of tradition. Ski-making traditions foster conservative designs under intensive selective pressure as hunters rely heavily on skis for mobility throughout the winter hunting seasons. Specific designs were reproduced with high fidelity at the scale of the dialect community, with historical data indicating that they were still being reproduced according to a distinctive format for at least a century. Hunting extensively in heavy snows far away from settlements can be a risky business; thus, in some cases, it pays to be conservative, even while leaving room for tinkering.

Third, despite survival depending upon fidelity to tradition, innovations can be tracked. For example, adding cloth covers around the ski binding was a new addition to the overall design, and the community under study was still experiencing an intensive process of experimentation and innovation, with early signs that some more effective variants were being copied more widely, and may eventually reduce the high levels of current variability observed. Imitation can facilitate rapid and widespread change.

Finally, other material traditions were being reproduced in very different ways, which prevented coherent historical lineages from forming. The best example of this phenomenon was seen in the construction of raised cache houses used for storing supplies and equipment. Construction is highly pragmatic, involving diverse sets of materials and construction steps in an almost random manner, resulting in no coherence in this tradition at any social or spatial scale.

Overall, these results indicated that each tradition had been propagated in very different ways, and while these patterns are complex and variable, they can be rendered understandable (and in most cases explainable) through cultural transmission theory.

This case underlines the fact that cultural traditions can indeed be characterized by both a stern continuity and serendipitous change, and that the dynamics between the two are constantly shifting. One generation's accidental discovery or personal design idiosyncrasy can become the next generation's tried-and-true method for success; by the following generation, it has become sacrosanct. Once we acknowledge these dynamics and account for at least some of the change by way of careful tracking, it becomes quite

impossible to conceive of most cultural traditions as in any way static.

### *Case 2: Tracking a Historical Genealogy of Cultural Traditions on the Pacific Northwest Coast*

While not in the Arctic, the adjacent northernmost Northern Temperate Zone of the Pacific Northwest Coast comprises a maritime core area (Fig. 3), which in this case extends south from Yakutat Bay in Alaska. At its northernmost latitudes, seasonal cold temperatures and weather conditions are extreme, requiring highly specialized knowledge and technologies for survival, which make it a relevant case setting for the present discussion.

Large-scale ethnographic surveys were conducted in most parts of western North America in the first half of the 20th century (Jorgensen, 1980). These generated high-resolution trait-based surveys that are now ideal for analysis of diversification and change in material culture traditions. Significant attention has been given to societies of the Pacific Northwest Coast. This region was occupied by sedentary and socially complex hunter-gatherer communities largely sustained by maritime and riverine economies and renowned for their rich material and architectural traditions.

Ethnographers have long noted the major differences in the building traditions along different sections of the Northwest Coast. Construction of longhouses was socially coordinated and involved males, with many generations of the community subsequently inhabiting the buildings. Phylogenetic analysis of these collective social traditions by Jordan and O'Neill (2010) indicate that they evolved via branching processes. Local lineages of specific traditions tended to follow language history as well. These associations were less clear in the northernmost areas, which were defined by matrilineal kinship and the greater movement of males between houses after marriage. In contrast, the patterns were strongest in the south, where patrilineal and patrilocal kinship were dominant.

Higher-resolution follow-up work was conducted among the Coast Salish (Jordan, 2015) and again indicated that their plank-built longhouses had also evolved via phylogenetic branching processes (the result of passing along TK of house-building techniques from generation to generation). As a case in point, these architectural lineages also tracked local language history. In contrast, other traditions including canoe-making and textile manufacture evolved in different ways. The wide sharing of textile-making traditions across the region was particularly interesting, given that this was a female craft, and women were known to move between houses, settlements, and even dialect communities after marriage. In other words, effective communication of TK across generations and communities was key.

This case study illustrates how settlement and kinship networks serve to structure cultural reproduction in distinctive ways. Large-scale coordinated material

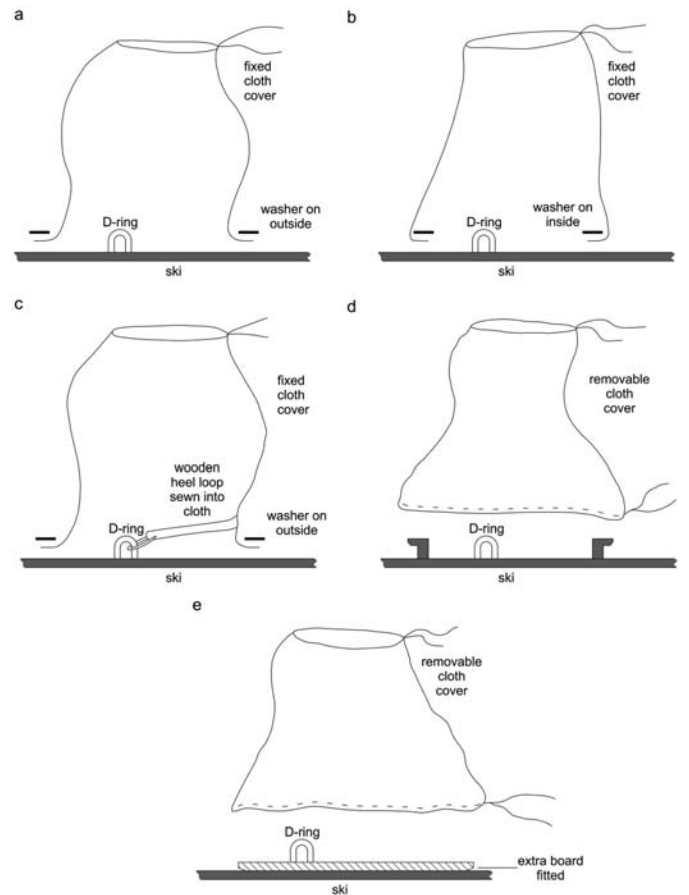
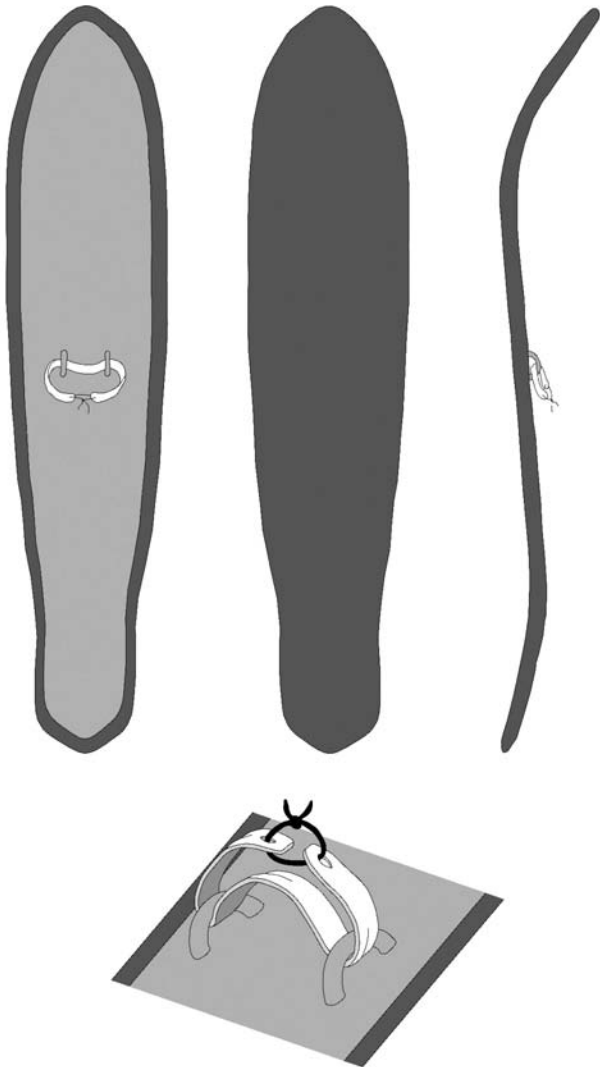


FIG. 2. Top: Khanty ski-making traditions in Northwest Siberia (after Jordan, 2015). Bottom: The skis have evolved as a coherent design whose distribution maps onto dialect boundaries, while the bindings and cloth covers are still evolving (after Jordan, 2015). Images used with permission from the University of California Press.

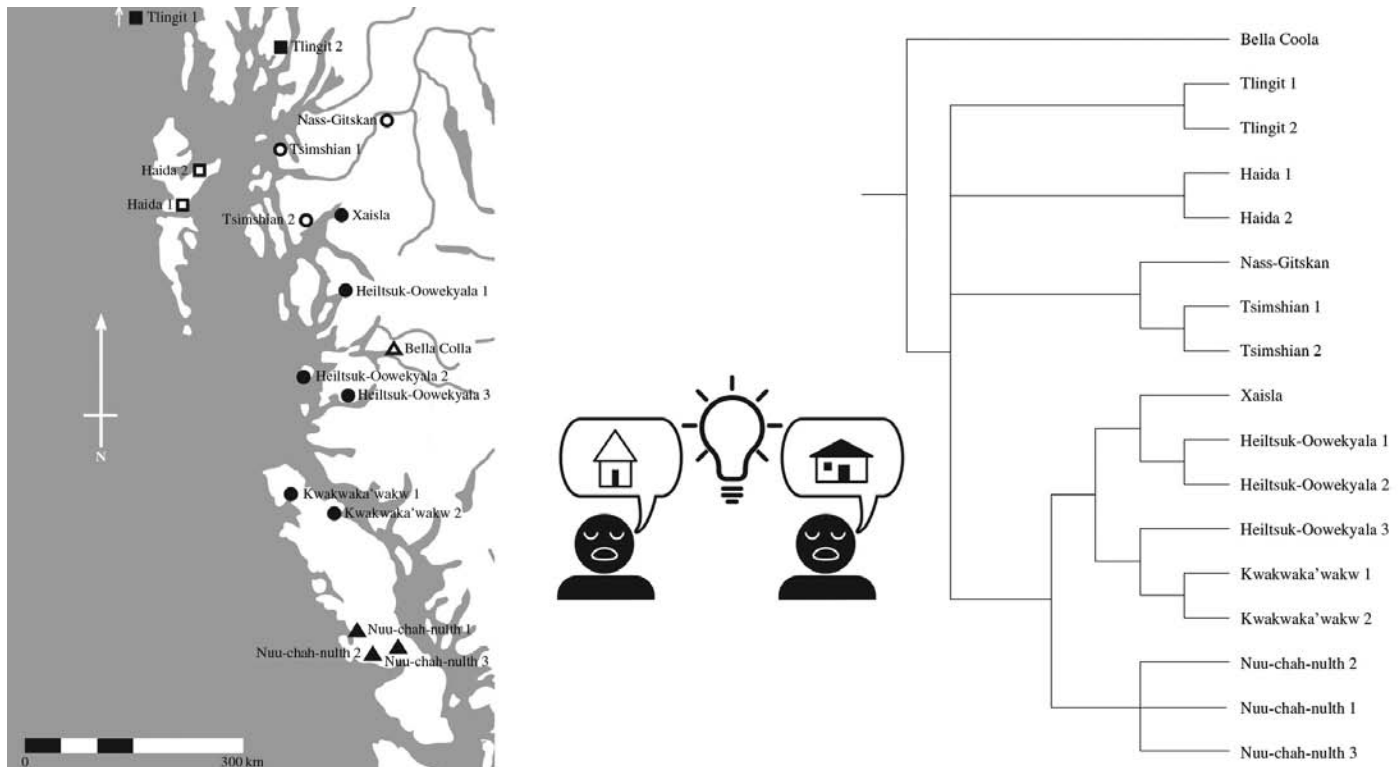


FIG. 3. Left: Location map of various ethnolinguistic communities on the Pacific Northwest Coast (after Drucker, 1950). Right: Pacific Northwest Coast language tree based on qualitative assessment of linguistic diversity (after Thompson and Kincade, 1990). Housing traditions were found to be more closely parallel to language phylogeny in the south of the region, where male work crews tended to stay in the same locations over more than one generation.

traditions like house building may have a greater tendency to evolve as branching lineages that may also track language history (e.g., O'Neill, 2013), together forming a bundle of core traditions. In contrast, other traditions have their own, often more contingent, descent histories. The notion of a static set of cultural adaptations is again thwarted here, as this study suggests that cultural traditions catalyse cultural change as well, in some cases more significantly than environmental factors.

### *Case 3: First Peopling of the Eastern Arctic: Influence of History vs. Environment on Material Traditions*

The prehistory of the North American Arctic is defined by a series of major dispersal events. The first involved the peopling of the Americas in the Late Pleistocene. However, none of these groups were able to settle the eastern Arctic, which was still blocked by the Laurentide Ice Sheet (Friesen and Mason, 2016). By the mid-Holocene, the dispersal of the Arctic Small Tool tradition (ASTt) after 4500 BP marks the first human presence in this vast territory (Fig. 4). With likely origins in eastern Siberia around 5500 BP, it is generally accepted that after crossing into Alaska, dispersing ASTt groups would have been small, isolated and highly mobile. Exactly how their cultural traditions evolved as groups moved into new areas remains poorly understood.

While the lack of other human populations in the area at this time would rule out cultural exchange, it was generally assumed that adjustments would have been made in relation

to local environmental demands, and that historical signals would not be preserved. A cultural phylogenetic approach has been used to examine the macroscale evolution of the ASTt phenomenon as it spread across the eastern Arctic (Prentiss et al., 2015). That study used archaeological sites as the main unit of analysis, focusing on inventories of lithic tools and site features pertaining to construction of living spaces and the organization of technology. In the eastern Arctic, these kinds of materials often represent the only extant materials available for archaeological analyses.

Surprisingly, local ecological conditions (temperature, productivity, precipitation) appear not to have exerted any detectable influence on the evolution of ASTt material traits. Deep cultural lineages appear to have evolved via branching processes by descent with modification from a common ancestor. In this case study, it can be inferred that a form of cultural inertia was at play within the ASTt, in which local groups seem to have gotten 'locked in' to producing traditional technologies (i.e., TK) that may not have fit well, adaptively speaking, to changing environments and environmental conditions. These results indicate the fragility of cultural propagation within small groups, which are always vulnerable to random loss of potentially useful traits. Indeed, the study shows that the cumulative loss of technological traits appears to have been a constant feature of the ASTt dispersal. This feature has been found to also have been the case among other Paleo-Inuit cultural complexes as well (McGhee, 1996; Maxwell, 1997), which should remind us of the value of flexibility in

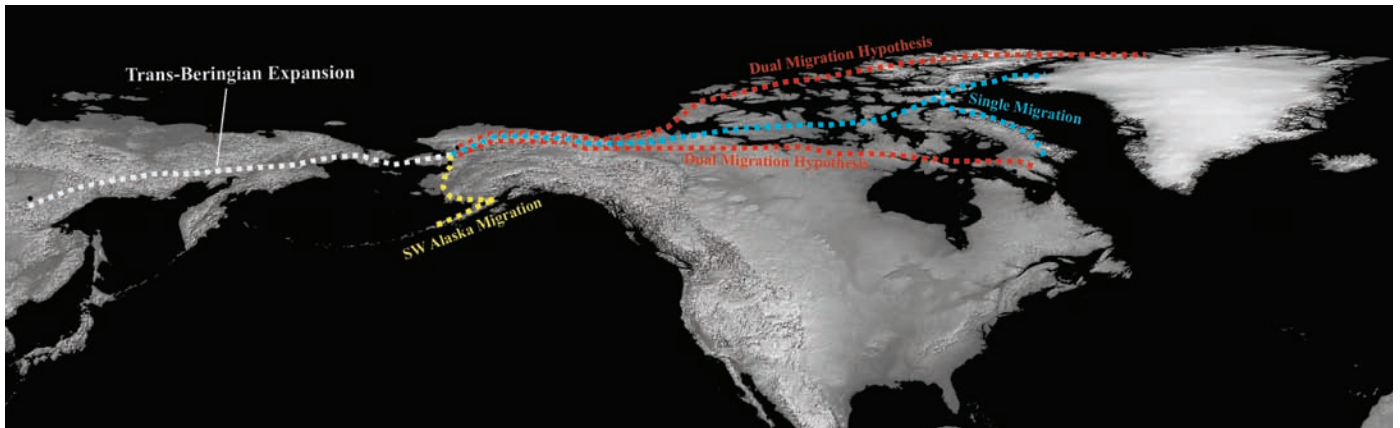


FIG. 4. Map of proposed ASTt dispersal routes and cultural lineages (source Prentiss et al., 2015; Elsevier).

the adoption, maintenance, or loss of certain technologies among still relatively small populations in the modern Arctic. This case demonstrates that assessing cultural change and continuity by tracking patterns of evolutionary descent with modification deeper into prehistory and across very wide regions in the Arctic is not only possible but could lead to wholly new studies examining museum collections and other untapped legacy data. The evolutionary approach allows us to restructure data in a way that controls anew for recovery bias and lacunae.

#### *Case 4: Thule Inuit Dispersals: Diversification of Multiple Traditions*

Related research by Prentiss et al. (2018) has focused on the later cultural traditions that were involved in the rapid long-range Thule Neo-Inuit dispersal event, which originated in the Bering Strait and eventually radiated out into the Eastern Arctic, reaching Greenland around AD 1000 and replacing previous Paleo-Inuit Dorset groups in the region (Friesen, 2013; Raghavan et al., 2014; Friesen and Mason, 2016). The Thule groups practiced a new kind of adaptation to Arctic environments focused on the hunting of large sea mammals in open water utilizing umiaks (large skin boats) manned by hierarchically organized and specialized crews. With better archaeological preservation at many early Thule sites, Prentiss et al. (2018) focused on the evolution of multiple material traditions—harpoon heads, stone tools, and architectural features—and examined the extent to which cultural inheritance versus local ecological context had impacted on designs.

Prentiss et al. (2018) demonstrated that each tradition evolved in its own way. Harpoon designs evolved entirely via cultural inheritance processes. However, lithic assemblages, architectural features, and the combined category of architecture and stone tools had evolved under the influences of both ecological and cultural factors. Prentiss et al. (2018) conclude that the cultural ancestry of these pioneering groups continued to influence the design of material traditions, albeit in different ways, and that ecological factors alone could not account for all the

observed variability. Additionally, local ecological factors were not able to explain all the variability in the material traditions, and the specific cultural history and genealogy of each tradition also played a role. In other words, cultural inertia was likely at play. Willerslev (2009:285–286) has identified a relevant parallel example of such a schism between cultural practice, contemporary ecology, and (mal) adaptation at play in the Siberian Yukaghir's maintenance of elk-hunting practices in the absence of wild reindeer. In both the archaeological Thule and the contemporary Yukaghir examples, knowledge of existing cultural technologies as well as knowledge about the immediate environment both played distinct roles in relation to change (or failure to change; see also Riede, 2011a).

These findings show that climate and culture have parallel histories, and assessing the adaptive value of a given TK practice can only really be done by looking at that history and evaluating whether any given behaviours or technologies contributed positively to the success of a given society (either via ecological and economic or social pathways). Cultural inheritance is extremely important. In some cases, it trumps ecological practicality—cultural inertia can be a powerful driver of both persistence and diversity. In many cases, technologies or ideas are discarded when no longer functional, while others may persist for entirely different reasons. This study also highlights cultural change as a process of not just adaptive, but neutral and sometimes even maladaptive outcomes. Recognition of this is vital to our understandings of contemporary TK, because it reminds us that we must appreciate that while some aspects of culture can be flexibly adjusted to adapt to given circumstances, others can be retained, maintained, or even dropped to accommodate any number of things, such as to support group identity, uphold social structure, or adjust subsistence mobility due to changing conditions. TK is not static, and traditional does not mean unchanging.

#### *Case 5: Sharing Stories: Arctic Folklore Traditions*

Ross and Atkinson (2016) examined the presence or absence of 45 distinct folktales in the cultural repertoires



FIG. 5. Approximate geographic locations of the 18 groups: 1 – Chukchi, 2 – Siberian Yupik, 3 – Bering Strait, 4 – Nunivak Island, 5 – Mainland Southwest Alaska, 6 – Northwest Alaska, 7 – North Alaska, 8 – Koniag, 9 – Chugach, 10 – Mackenzie, 11 – Copper, 12 – Caribou, 13 – Netsilik, 14 – Iglulik, 15 – Quebec, 16 – Baffin, 17 – Labrador, 18 – Greenland. Coloring shows a simple Kriging interpolation of the first axis of variation of principle coordinate analysis (PCoA) of folktale data (Ross and Atkinson, 2016; with permission).

of 18 Indigenous ethnolinguistic communities located along a 6000 km transect running from Chukotka to Alaska, Canada, and into Greenland (Fig. 5). Most communities maintained just over 18 folktales, but one had just five (Nunivak Island) and others had as many as 28 (Northwest Alaska). Despite the large distances, many folktales can be seen as shared over large areas, with nearby groups having the most in common. However, the causes of these geographic associations are unclear and could relate to a shared cultural ancestry or to geographic proximity and the sharing of folktales between adjacent groups. Given that many of these groups were direct descendants of the Thule Inuit migration (see Case 4), the researchers used language divergence to index cultural ancestry. Data visualization with NeighborNet indicated conflict in the dataset, suggesting that folktale variation between the groups had not evolved via a simple tree-like branching pattern. Interestingly, Mantel tests indicated that both linguistic relatedness (cultural ancestry) and geographic proximity independently accounted for overlaps in local folktale inventories. Ross and Atkinson (2016) interpret these results as indicating a combined process of sharing of folktales between adjacent groups, but also the generation-to-generation inheritance of folktales within particular communities. On this basis, they conclude that each folktale probably had its own independent history, with many stories originating in different geographic locations.

Overall, Ross and Atkinson (2016) argue that their study highlights how remote Arctic populations maintain mechanisms to share cultural information across group boundaries and over large distances, which serves to raise the effective population size for social learning of orally transmitted culture much higher than the nominal group size. This continuity, they conclude, was likely the result of strong vertical transmission of stories within close-knit groups. Theoretically, this widespread sharing consistency of orally transmitted ideas would mitigate against the chance loss of valuable traditions (traits) and may suggest that long-range interaction networks may have served to support cumulative cultural evolution in small and other remote groups (see Case 3). However, Ross and Atkinson (2016) also highlight that other cultural traditions may have

evolved in very different ways (cf. Cases 1 and 2), and that this folklore study merely identifies that such intergroup transmission pathways must have existed.

One important observation in this regard is that the 11–13 folktales identified by Sheppard (1998) on which the authors based their analysis and that were shown to have correlates spanning from Chukotka to Greenland (and all points in between), arguably convey quite important cultural core-level information. That is, information broadly integral to maintaining social and ecological stability (cf. Minc, 1986; Scalise Sugiyama and Sugiyama, 2009), while other, more regional stories tend to exhibit more eccentric subject matter. For example, the story of “Sun and Moon” treats incest and its consequences; “Salmon Father” treats the creation and preservation of key subsistence resources; “Flood Myth” is a cosmological origin story that may convey information regarding tsunamis; “Monster Baby” and “Sea Goddess” in many places describe the origins of Sila and Sedna (respectively), the first a personification of weather presented as a petulant and unpredictable giant child, and the latter the goddess of the seas and controller of the souls of key animal resources; “Abused Wife Marries the Moon” treats the consequences of spousal abuse, and so on (see Sheppard, 1998:156–160). In short, the overarching themes (i.e., TK) of these particular tales were central adaptive lessons to everyday life (cf. Scalise Sugiyama, 2001).

Ultimately, this case shows how one feature of TK—oral traditions—was highly transmissible over long distances with relatively high fidelity (what the authors refer to as “bandwidth”). Given the distances involved even between relatively geographically close groups, we may surmise that this was the case for a very long time. Within these distances, details of some stories changed in place but the important information transmitted in them remained. Understanding the way stories alone can spread over such a vast region can have direct relevance in the digital age and reminds us that memes and ideas can spread rapidly, immediately useful or not. And, importantly, they can be incorporated into existing TK schemes in specific places as appropriate. Ancestral traditions need not be replaced or relegated to some bleak traditional shelf, but can be

nurtured and protected as vessels, or as integrative devices, for new and relevant knowledge. Of course, this helps us to understand better what happened in history, but it is also an indication of what might continue to happen in the future.

#### RESEARCH OUTLOOK IN A RAPIDLY CHANGING WORLD

In the modern era, the circumpolar North and its residents are under massive pressures from HIREC. TK is not going to reverse the current climate crisis, at least not in the near term (IPCC, 2021). But TK clearly holds valuable insights into how communities have coped with changing conditions and may cope with these pressures moving forward (cf. Nakashima et al., 2012). We need an integrative scientific understanding of TK as contextual and mutable information systems if we hope to develop effective long-term resilience strategies. We must also consider critically that understandings of TK must be rooted in deeper time perspectives if the relevant knowledge is going to be applied in adaptive ways in response to highly uncertain futures (e.g., Boers, 2021). Indeed, as a global community we need to urgently rethink how contemporary and future climate change (in the Arctic as elsewhere) is pushing us into non-analogue conditions in which the notion that TK (or any knowledge!) can serve adaptive purposes may be erroneous (Kaaronen et al., 2021). How then can a cultural inheritance approach help support these efforts? We suggest that evolutionary studies utilizing archaeological and legacy data, supplemented wherever possible by environmental data and drawing insights from studies of contemporary human-environmental dynamics offer novel understandings that can aid in resilience planning in a changing Arctic (and beyond). At the very least, rigorous studies along these lines will school our intuitions and foster creative solutions for what can be done in the future.

A historically informed circumpolar comparative studies agenda demands that we better understand diversity, change, and resilience in the face of HIREC if we are to appreciate the changes we observe in the archaeological record and vice versa.

#### *Long-term Cultural Inheritance in Non-Equilibrium Arctic Ecosystems*

Despite emerging opportunities, one major knowledge gap looms large. The environments of the circumpolar regions are highly variable and cannot be understood as a uniform strip that supports broad cultural uniformity. High-latitude environments are inherently unstable and only more so under the effects of HIREC. They are subject to major and unpredictable fluctuations in animal population size and location and constant shifts in sea ice and other critical variables such as vegetation zones, which generate a range of interlocking risks for humans that persist over multiple generations (Desjardins and Jordan, 2019). While

the dramatic changes in this regard in the modern Arctic are certainly exacerbated exponentially by HIREC, these fluctuations merely show just how fragile the ecological and environmental systems in the Arctic really are (and have been). How cultural inheritance and especially contrasting sets of cultural traditions evolve in such unstable ecosystems is still far from clear, yet it emerges as a vital question as we strive to understand long-term human responses to Arctic change (IASC, 2016). There is an increasing realization that human action has long had an impact and a lasting legacy on Arctic environs (Normand et al., 2013). Yet detailed studies of how specific cultural traditions have not only been shaped by but also actively shaped high-latitude ecosystems remain to be conducted. Much more high-resolution longitudinal research is needed to understand how a range of traditions can and will evolve over extended time scales across a range of social-ecological systems under pressure from different climatic shocks or environmental trends (e.g., Mason, 2016, 2020; Desjardins et al., 2020b).

There are potential cultural evolution methodologies and approaches (e.g., phylogenetics and cultural transmission theory) to tackle these issues. While the construction of cultural or linguistic trees is an important analytical exercise in itself, a well-supported phylogeny can provide a foundation for what in biology is known as the “comparative method” (Harvey and Pagel, 1991; Pagel, 1992), also known as a “natural experiment” (Diamond, 2005:17). This method offers “one of biology’s most enduring sets of techniques for investigating evolution and adaptation” (Pagel and Meade, 2005:235) and has been effectively shown to be applicable in ethnological studies as well (Mace and Pagel, 1994). In the context of cultural studies, it searches for correlations amongst certain social or technological traits. Such correlations can then be examined for causation in terms of which trait changes may drive changes in others (e.g., which variables are independent, and which ones are dependent).

Fortunato and Jordan (2010), for instance, have used such an approach to investigate the evolution of different forms of human social organization, including the links between marriage and residency rules in Oceanic and Indo-European societies. In this and other case studies, formal comparative methods provide a means to control for the historical relatedness of the units under study (species, genera, cultures, groups, sites, etc.) when looking for correlations, be they internal to specific cultures or in reference to external environmental parameters. The Arctic offers outstanding opportunities for such approaches that together can contextualize and even inform responses to present and future HIREC. The collection of approaches we sketch out here stand to deliver a robust evidence base for building scenarios for such longer-term adaptations (cf. Ford et al., 2010; Riede, 2017), with widespread applicability across the circumpolar region.

*Wider Societal Relevance: Dynamic Historical Perspectives on Traditional Knowledge*

The kind of research we propose here can start to develop wider societal relevance, which is especially important in relation to providing support to long-term social identities and strengthening scenario planning exercises and mitigation efforts that urgently need longer-term and more dynamic insights into how different cultural traditions evolved and changed over multiple generations (Desjardins et al., 2020a, b). These problems and identification of potential solutions are increasingly studied from within a resilience framework that looks at the extent to which local social-ecological systems can adjust to pressures (AC, 2016). Yet, the fluid role of TK, changing traditions, and human agency under rapidly and in many cases compounding changing circumstances remains an open prospect for further research. In short, much can still be learned from Indigenous communities and their histories in both the present and the past. Focusing on TK as ideas with histories is one potentially powerful way to do this. It seems simple to acknowledge this, but we are approaching futures in which we will need these ideas, with a contextual inkling of where they come from and where they may help us go.

Today, reserves of TK guide how the environment and its resources are used and understood in many local communities, providing a knowledge base that was, is, and will be crucial for adapting to changing environmental conditions (Berkes et al., 2000; Gómez-Baggethun et al., 2013; Haruyama, 2020). Such knowledge traditions build on many generations of cumulative cultural evolution. We have shown that they are not static, but flexible and dynamic, building on centuries (if not millennia) of history. Their capacity to help groups identify problems and facilitate behavioural flexibility were and will be integral to adjusting to a changing Arctic (Nakashima et al., 2012:79–87; AC, 2016:42, 100). Yet TK is also highly vulnerable (Pearson et al., 2021) and should not be conceptualized as timeless. The current problem is that the ways in which Arctic cultural traditions evolve in both social and environmental settings are still poorly understood, yet such understandings are vital as contemporary assumptions of what constitutes normal or traditional are prone to shifting baselines. A conceptual focus on TK as intergenerationally transmitted knowledge and know-how also shifts attention to the role of education and, soberingly, to resilience as an emergent property that unfolds optimally at the pace of generational changes. We hope that this paper makes a first step towards illustrating how cultural evolution and transmission studies can help close this knowledge gap. Many scenario-planning exercises risk missing out on identifying a wider range of possible future scenarios and also generate a restricted set of potential response, planning, and mitigation strategies by ignoring the fact that TK is ideas with histories. Archaeology, history and ethnography, which are united by a shared focus on the modelling of cultural lineages,

emerge as the critical resource for understanding long-term patterns in the cultural and technological traditions that support or erode the resilience of Arctic communities in the face of climate change.

## CONCLUSIONS

Interest in circumpolar comparative studies has re-emerged most acutely in the context of accelerating climate change. Focused on better understanding the drivers of vulnerability and resilience in Arctic social-ecological systems, we argue that the field needs to engage in more detail with the dynamics of cultural inheritance and long-term decision-making processes in order to reach its transdisciplinary potential. We suggest that cultural evolution and transmission studies are fruitful ways of looking at the deep-time dynamics of TK. We conclude that although a small but insightful body of empirical work has been generated to date and provides a coherent body of proof-of-concept in this regard, much more work remains to be done using a wider array of comparative methods and drawing from legacy datasets. Most importantly, the priority needs to be research that integrates analyses of cultural traditions with the non-equilibrium characteristics of northern ecosystems (e.g., Prentiss et al., 2015, 2018). Better understanding of these coupled processes can significantly contribute to future planning and mitigation efforts (e.g., Ford et al., 2010) in vulnerable regions like the Arctic, which overwhelmingly tend to rely on very recent cultural and ecological baselines that in turn reproduce static and ahistorical considerations of traditional ecological, technological, and cosmological knowledge. We need more research on decision-making in the context of human-environment interactions under changing conditions over time. Coupled, archaeology and ethnology can provide this research, which can be fruitfully accomplished by a renewed circumpolar comparative studies agenda aimed both at understanding the past and developing insights for the future.

Ultimately, we need to recognize TK as reflecting the latest cultural manifestations of deep temporal traditions—ideas with histories. These unique and contextual histories can inform future decision-making and also help us better cope with the HIREC-induced struggles ahead. We need to better appreciate the rich, particular, and situated histories of TK, which includes acknowledging its potential fragility and capacity to change while above all recognizing its powerful transformative prospects for coping dynamically with an ever-changing Arctic.

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Throughout this work we have in places used the outdated term “Eskimo.” We fully acknowledge and agree that this term is inaccurate in describing varied Arctic societies across the North American continent. We repeat this term only in sections that describe how the term was used historically and conceptually to describe diverse Arctic peoples from the Bering Strait to Greenland.

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