

Toward more ethical engagements between Western and Indigenous sciences

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Abstract

There is growing interest among Western-trained scientists in engaging with Indigenous sciences. This interest has arisen in response to social pressures to reckon with the colonial foundations of Western science and decentre Western ways of knowing, as well as recognition of the need to draw upon the gifts of multiple knowledge systems to address today’s many complex social and ecological challenges. However, colonial patterns and power relations are often reproduced at the interface between Western and Indigenous sciences, including the reproduction of epistemic Eurocentrism and extractive modes of relationship between settlers and Indigenous Peoples. This paper seeks to support Western-trained scientists to recognize and interrupt these patterns in order to create the conditions for more ethical, respectful, and reciprocal engagements with Indigenous sciences. We also offer a map of the different ways that Western sciences have thus far engaged Indigenous sciences. We particularly highlight the emergent possibilities offered by a reparative approach to engagement that emphasizes the responsibility of Western science to enact material and relational repair for historical and ongoing harm, including by supporting Indigenous self-determination and sovereignty in science and beyond.

Key words: epistemic pluralism, Indigenous knowledge, colonialism, epistemicide, responsibility, reparation

With the mainstreaming of commitments to reconciliation, as well as growing calls for decolonization and #Land-Back, universities in what is currently known as Canada, the US, and many other settler colonial nations are being called to account for their historical and ongoing complicity in Indigenous dispossession, genocide, and epistemicide. In the context of efforts to address global climate change, biodiversity loss, and other threats to the health of the planet’s lands and waters, Indigenous scholars have also emphasized the need to center Indigenous knowledges and uphold Indigenous rights, such as those outlined in the UN Declaration on the Rights of Indigenous Peoples (UNDRIP) (McGregor et al. 2020; Hernandez et al. 2022; Ignace et al. 2023; Redvers et al. 2023). In response, university faculties and departments are increasingly expected to take steps toward Indigenization

and decolonization, and there is growing interest in Indigenous knowledges on the part of non-Indigenous researchers and policy-makers.¹

¹While the meanings of these terms in higher education are contextual and contested (Tuck and Yang 2012; Andreotti et al. 2015; Gaudry and Lorenz 2018; Brunette-Debassige et al. 2022), Indigenization can be broadly defined as the resurgence and (re)centering of Indigenous ways of knowing, being, and relating (Grafton & Melançon as cited in Brunette-Debassige et al. 2022), while decolonization can be defined as the interruption and unravelling of colonial ways of knowing, being, and relating in practice and policy, accompanied by material restitution and relational repair. While these two terms are often conflated, many suggest that they are distinct but necessarily parallel processes.

We write as a group of settler and Indigenous scholars, practitioners, and graduate students who have sought to understand the complexities, challenges, and possibilities that typically emerge when traditionally Western fields of study begin to confront colonialism and engage with Indigenous knowledges and communities. In this perspective article, we examine how enduring colonial dynamics operate in Western science fields while acknowledging that in addition to common patterns across these fields, there are also differences between them. In particular, we have observed that even as more scholars trained in Western sciences move away from the outright dismissal of Indigenous sciences, efforts to engage Indigenous sciences and other Indigenous knowledges do not always unfold in generative ways.

As many Indigenous and other critical scholars have observed, engagements with Indigenous knowledges often end up circularly reproducing, rather than challenging, “business as usual” (Ahenakew 2016; Daigle 2019; Gaudry and Lorenz 2018; Grande 2018; Liboiron 2021a, 2021b; McAllister et al. 2022; Reid et al. 2022, 2024). Beyond naming the colonial patterns that are commonly repeated in the context of this work, albeit often unconsciously or unintentionally, we also seek to support Western-trained scientists to interrupt these patterns and identify more intellectually and relationally rigorous pathways for confronting colonialism and thereby pluralizing the possible futures of science for planetary well-being.

Although we emphasize the relationship between Western and Indigenous sciences in this text, we also acknowledge that this is just one part of a wider process of addressing the multiple, entangled layers of colonialism, racism, sexism, and other forms of inequity in the sciences (Liboiron 2021a; Prescod-Weinstein 2020). Following the decolonial imperative to interrupt presumptions of epistemic universality, we also note that we as authors are situated at a university in the Global North in what is currently known as Canada and writing to a presumed audience of scholars in the Global North. While the colonial dynamics we describe are likely to have some resonance with colonial dynamics that operate at universities in the Global South, we underscore the need to provincialize our intervention. The relevance of this work for other contexts is most appropriately determined by those working within those contexts.

Indigenous scholars, including Indigenous scientists, have long observed that the unfolding climate and nature emergency, and many other pressing social and ecological challenges, have their roots in colonial patterns of relationship, and the imposed universalization of one (Western) way of knowing and being (Davis and Todd 2017; Hernandez et al. 2022; Huni Kui 2022; Hunt 2022; Jacobs et al. 2022; McGregor et al. 2020; Whyte 2018). We suggest that if Western-trained scientists are to produce relevant, rigorous, and responsible knowledge for addressing these challenges, they will need to interrupt this inherited monoculture of inquiry and unlearn ethnocentric assumptions about the superiority, objectivity, and universality of Western sciences. Addressing these challenges will also require learning how to ethically coordinate the gifts of Western sciences with the gifts of other knowledge systems while accepting that this coordination will in-

volve many complexities, tensions, uncertainties, and incommensurabilities rather than result in “universal” truths.

To support this work, in this article, we offer a social cartography that maps how Western sciences have thus far engaged Indigenous sciences, as well as emerging possibilities for engagements that seek to recalibrate Western sciences toward epistemic humility and to create the conditions for inter-epistemic dialogues grounded in trust, respect, reciprocity, consent, and accountability (Whyte 2020). We begin the article by reviewing how we approach “Western sciences” and “Indigenous sciences”, and then offer five starting points from previous lessons learned that can help fast-track un/learning in efforts to confront colonialism. We then present the social cartography of Western sciences’ engagements with Indigenous sciences.

What are Western and Indigenous sciences?

The meanings of terms like “Western science(s)” and “Indigenous science(s)” are contested, contextual, and plural. Both Western sciences and Indigenous sciences contain many internal heterogeneities and multiple epistemological traditions—hence, our use of the plural *sciences*. It is particularly important to emphasize the diversity of Indigenous knowledges, given the tendency of Western institutions to reproduce forms of pan-Indigenism that flatten the diversity within and between Indigenous communities and knowledge systems by assuming they are all the same (Marsden et al. 2020). Indeed, Indigenous Peoples have their words in their own languages for the knowledges that are deemed to fall under the broad category of “Indigenous sciences”. The general category of Western sciences also contains much diversity.

For the purposes of this article, we offer broad definitions of both Western and Indigenous sciences; however, we also note that the desire for stable and universal meanings is part of a logocentric colonial apparatus of knowledge that seeks to impose coherence and consensus on a complex, constantly shifting, pluri-vocal world, much of which is unknowable. This desire also denies the equivocal, contextual, and polysemic nature of language and the ways language can be mobilized differently depending on who is using it, when, where, and how. The definitions that we offer here are therefore not intended to be timeless, universal, or definitive; rather, they are partial and provisional and were chosen based on what we have discerned to be most relevant for higher education in settler colonial contexts in the current moment. Finally, although we emphasize here the distinctions between Western and Indigenous sciences, these do not exist as a binary; there are also many overlaps and potential synergies between the two.

Western sciences can be understood as the most dominant, institutionalized form of scientific understanding, inclusive of disciplines within the natural, health, and social sciences, all of which centre scientific rationality as the foundation of their epistemic beliefs despite differing in their specific methodological practices and the focus of their inquiry. Although Western sciences tend to assert that they are “place-

less”—that is, offering a bird’s-eye “view from nowhere”—in fact, they emerge from and are situated within very specific cultural and historical contexts and were then imposed on the rest of the world as if they were universal. Western sciences are derived from the Euro-American philosophical traditions of positivism and empiricism and are grounded in values of universality, objectivity, and neutrality (Haraway 1988; Harding 1993; Ogawa 1995; Stengers 2018; Liboiron 2021a, b; Hird et al. 2023).

Western science disciplines tend to treat humans as separate from the natural world and treat the natural world as an “object,” positioning humans (in particular, white/Western people) with authority and ownership over all other beings, including the Earth itself (Moko-Painting et al. 2023). This can lead Western-trained scientists to believe they are entitled to access “Indigenous DNA, bodies, and parts of land” in the name of scientific inquiry (Liboiron 2021a, p. 876). These disciplines also tend to assume their modes of inquiry are uniquely able to discover truths and produce knowledge to describe, measure, categorize, predict, and control the world and the universe as a whole in universal, value-neutral, and totalizing ways. In fact, it is often assumed within the frame of Western science that if a knowledge system *does not* claim to do this, it does not really count as knowledge at all (Blaser 2018; Mika et al. 2020).

We define Indigenous sciences as sciences that are done for and by Indigenous Peoples and grounded in Indigenous worldviews, ontologies, and values (Cajete 1999; Michell 2005; Hatcher et al. 2009; Snively and Corsiglia 2016; Liboiron 2021b; Reid et al. 2022). Indigenous sciences may or may not take place in a Western-style academic or research setting. Rather than see science as something that stands outside of other knowledges, practices, and responsibilities, Indigenous sciences are generally approached in more holistic, integrative, and relational ways that have social, political, ecological, and spiritual implications.

Indigenous sciences do not position humans as exceptional or as having authority, superiority, or ownership over other beings. Instead, many Indigenous sciences position *humans as part of (entangled with) the world*. Thus, they also emphasize that knowledge itself is produced and shared relationally, not only amongst humans but amongst other-than-human beings as well. In this sense, within Indigenous sciences, other-than-human beings and the land itself are not treated as objects but rather as living entities, knowledge holders, and teachers that carry essential wisdom for living well together on a shared, finite planet (Ahenakew 2016; Marker 2004; McGregor et al. 2020). Because of the reciprocal relationships between humans, other-than-human beings, and the land, the health and futurity of Indigenous Peoples, lands, and knowledges are understood to be intertwined and require ensuring that Indigenous Peoples can access and fulfil their responsibilities to their territories.

Indigenous sciences are often assessed according to the extent to which they foster the well-being of humans, other-than-human beings, and the land; support relations of trust, respect, reciprocity, and balance between all beings; and uphold responsibilities to past, current, and future generations of all species (Hird et al. 2023). As a result, Indigenous sci-

ences have enabled Indigenous Peoples to ensure the collective health and well-being of their lands and communities for thousands of years. These sciences tend to be place-based, as they have been derived, adapted, and sustained through collective inquiry in specific territories across generations.

It is important to note that Indigenous Peoples are heterogeneous and have different orientations toward the word “science” (Stewart 2023), particularly in light of the colonial history of Western science. For instance, some advocate for the political imperative to claim the term “Indigenous science(s)” to contest the hegemony and presumed universality of Western sciences, while others resist the word “science” altogether, especially given its close association with Western science. Meanwhile, those who identify as Indigenous scientists “do, use, and refuse Western and Indigenous sciences along a rich spectrum” (Liboiron 2021b, p. 27).

The differences between many Western and Indigenous sciences are not just epistemological but also ontological, having to do with different orientations to the nature of language, knowledge, and reality itself. While a deeper dive into these distinctions is beyond the scope of this paper, we emphasize that the distinct ontological grounding of many Indigenous sciences may be invisible to many Western-trained scientists (Hunt 2014). If these ontological differences are not acknowledged, and (or) if the ontological grounding of Western sciences is asserted as universal, there is a significant risk that Indigenous sciences will be “grafted” onto Western ontological frames (Ahenakew 2016; Hird et al. 2023), resulting in “domesticated and sanitized forms of visibility for Indigenous modes of existence” (Mika et al. 2020).

Decentering rather than dismissing Western sciences

We want to make it clear from the outset that we are not writing *against* Western sciences. We sometimes find that when we start to talk about the need to confront colonialism in Western science fields, those who practice in these fields assume that we are dismissing Western sciences altogether, and subsequently become defensive. This is definitely not our intention. We are not questioning the value or importance of Western sciences. Instead, what we are questioning is the Eurocentric politics of knowledge that places Western sciences at the top of an epistemic hierarchy as the *most* valuable and important of all knowledges.

Although the processes of inquiry associated with Western sciences (e.g., observation, measurement, analysis, and deliberation that ultimately seek to describe what is presumed to be an already existing world) are not inherently harmful, they become harmful when people assert and wield them as if it were the only valid way of viewing the world. This claim positions Western sciences as if they were universal, objective, and superior to other (non-Western) sciences and other knowledge systems and ways of knowing. This ethnocentric and anthropocentric hierarchy of knowledge is upheld not only by Western scientists but also by institutional funding structures as well as cultural commonsense about which knowledges matter most, and who constitutes a legiti-

mate knowledge holder. Thus, part of the defensiveness that often arises in response to the call to confront colonialism may be due in part to the fact that Western-trained scientists have become accustomed to the premise and promise that Western sciences are exceptional, even though this is not always explicitly named. As a result, when we suggest that Western sciences are *equal to* rather than *superior to* other knowledges, it can feel like a demotion and even a dismissal, or people might inaccurately assume that we are suggesting that another knowledge system is actually the superior one.

A presumed hierarchy of knowledges leads to non-reciprocal cross-epistemic engagements. Different kinds of dialogue and collaboration might become possible if we understood knowledges relationally and contextually, rather than situated within an inherent competition for epistemic privilege. Understanding that each knowledge has contextual relevance rather than universal relevance can lead to an appreciation for a plurality of knowledge systems and to a recognition that different knowledge systems are indispensable *and* insufficient.

Western sciences are also harmful when they are used as a means to rationalize, enable, and extend the colonization of lands and peoples (Liboiron 2021a, 2021b). Western sciences are often expected to provide solutions to social and ecological problems, but they are rarely expected to address how they have contributed to creating those problems in the first place. Because Western sciences are positioned as exceptional, objective, and apolitical, they are often not perceived to be accountable for their social and ecological impacts—indeed, in many cases, these impacts are not acknowledged (Liboiron 2021b). Thus, in addition to inviting people to consider the politics of which and whose knowledges are the most institutionally and socially valued, we also invite people to consider another dimension of the politics of knowledge, which is a central consideration of many Indigenous knowledge systems: the extent to which a knowledge system generates knowledge that either enables or precludes the flourishing and well-being of current and future generations of humans and other-than-human beings.

While we recognize the risks of critiquing Western science in a moment when it is under attack from anti-intellectual forces, we emphasize that our approach is in no way aligned with these attacks, and that even in this complex and challenging context, it remains the responsibility of those trained in Western sciences to try and interrupt how their fields have been and continue to be complicit in colonial harm. In fact, we invite Western-trained scientists to consider that scholars of colonialism might see it as anti-intellectual to deny Western sciences' complicity in colonialism, given that there is extensive evidence to support this (Prescod-Weinstein 2020).

Five Starting points to accelerate Western-trained scientists' un/learning

In the process of our extensive research, teaching, and other personal and professional experiences with efforts to confront colonialism across various fields and sectors of society, we have sought to synthesize our own learning, and the

learning of others engaged in similar efforts. It is common for people to want to emphasize the successes and positive outcomes of this work, but we have found it is also important to learn from common mistakes and failures. Given the difficulty of interrupting the deeply ingrained (and often unconscious) colonial patterns and habits of knowing, being, and relating that many Western scientists have been trained and socialized to reproduce, it is almost inevitable that there will be mis-steps on the path toward more respectful, reciprocal relations and more accountable science. However, these mistakes carry high costs for Indigenous communities, and ultimately for all communities, both human and other-than-human, given their socio-ecological implications. Thus, it is important to learn from these mistakes so as to begin interrupting rather than continue reproducing them (Arshad-Ayaz et al. 2020; GTDF 2021). In this section, we identify five starting points that, if taken seriously, can accelerate the learning and unlearning process for those trained in Western sciences who are seeking to expand their capacity to confront colonialism.

- 1) Confronting colonialism in Western sciences entails going beyond the inclusion of Indigenous Peoples and knowledges: Settler colonial societies and institutions have not only *excluded* Indigenous Peoples and knowledges, they have also been developed at the *expense* of Indigenous communities, knowledges, and lands. Western sciences have historically been used to both justify and enact the domination of Western societies over non-Western societies, displace non-Western peoples from their territories, and seek their elimination (genocide). This has been done in part by dismissing the value and validity of non-Western knowledge systems, and even seeking to destroy those knowledge systems (epistemicide).

From the outset of European colonial expansion starting in the 15th century, Western sciences have been part of the colonial effort to catalogue and thereby control the world. These fields largely continue to presume entitlement to access, extract, and consume Indigenous life, land, and knowledges without obtaining Indigenous Peoples' free, prior, and informed consent, and without recognizing Indigenous Peoples' sovereignty and self-determination over their lands and knowledges (TallBear 2013; Liboiron 2021a, 2021b; Igance et al. 2023). Western sciences also largely continue to presume that humans are separate from nature, and positioned above it, rather than part of nature. This illusion of separation and superiority has enabled settlers to rationalize environmental destruction and extractivism (ecocide).

Thus, while ensuring the full participation of Indigenous scientists in Western institutions and Western science programs is essential, this alone will not repair the social and ecological harms that have been committed by Western sciences, nor repay the debts that are owed to Indigenous Peoples (Liboiron 2021a). Further, many inclusion efforts end up reproducing colonial patterns rather than interrupting them (Marker 2019). For instance, efforts by non-Indigenous scientists to "prove" the value of Indigenous knowledges using Western scientific methodologies "only further privileges

Western knowledge and positions Western knowledge as superior” (Swidrovich 2022, p. 196), by reifying the purportedly objective and universal standard by which all other knowledges should be evaluated. In this way, commitments on the part of Western sciences to “include” or “integrate” Indigenous knowledges often serve as euphemisms for assimilation (Ahenakew 2016; Reid et al. 2021).

2) Confronting colonialism in Western sciences entails paying attention to how inclusion can reproduce rather than interrupt business as usual: Given the enduring systemic hegemony of Western sciences and the subsequent enduring systemic marginalization of Indigenous sciences (along with other non-Western sciences), Western sciences often take a dominant role in “collaborations” with Indigenous sciences/scientists, particularly in the context of white settler-dominated Western institutions like universities (McGregor 2000, 2005; Simpson 2004). This has sometimes led to a sense that Western sciences’ engagements are oriented by the extractive question “What can (Western) science gain from Indigenous knowledge?” (Hird et al. 2023, p. 2), rather than by possibilities for genuinely reciprocal learning, collaboration, and relationship building.

In their efforts to “include” Indigenous sciences in their research or teaching, settler scientists have at times extracted Indigenous sciences from their place-based contexts and imported them into universalizing Western frames and contexts. In these instances, Indigenous knowledges are treated as “raw data” to be processed and possessed by Western sciences (Johnson et al. 2016; Klenk et al. 2017; Chakraborty and Sherpa 2021; McAllister et al. 2023). This has led to “biopiracy” through which ownership of Indigenous knowledges, and in some cases, Indigenous Peoples’ genetic material are claimed by non-Indigenous scientists and commercialized by non-Indigenous corporations (Ignance et al. 2023).

Through inclusion efforts, Western-trained scientists have also selectively engaged only elements of Indigenous science that are understood to be similar to Western science, and that can be “confirmed” by Western science (Ahenakew 2016); ignored the spiritual foundations, ethical obligations, and political implications that come with Indigenous knowledges (Simpson 2004; Hird et al. 2023); displaced Indigenous knowledge holders by claiming expertise in Indigenous science (i.e., including Indigenous knowledges without Indigenous people) (Marsden et al. 2020; McKay and Grenz 2021), or conversely, expected Indigenous scientists to abandon Indigenous science and adopt Western science (i.e., including Indigenous people without Indigenous knowledges) (Marker 2019); tokenistically invited an Indigenous person to join a research project at the last minute to tick their “diversity” box (McAllister et al. 2022); and instrumentalized the insights of Indigenous sciences as “add-ons” to “fill in the gaps” of Western science instead of respecting Indigenous intellectual sovereignty and recognizing the integrity and equality of Indigenous sciences as knowledge systems that have their own internal measures of validity, quality, rigour, and relevance (Reid et al. 2022).

3) Confronting colonialism in Western sciences entails developing reflexivity about the historical and ongoing impacts and responsibilities of one’s institutions, field, and self: Like many other fields of study and practice, Western sciences have contributed to and benefited from the creation and reproduction of a social, political, and economic system that is grounded in ecological unsustainability and colonial violence. Western sciences were not merely a beneficiary or a bystander of colonialism but played an active part in its foundations: “scientific racism played an integral role in the justification of colonial policies by inventing racial categories” (Gebhard et al. 2022, p. 4). As Michif researcher Max Liboiron (2021a) notes, “These are our inheritances, whether we like them or not” (p. 876).

With these ongoing legacies of harm in mind, the work of confronting colonialism in Western sciences is not about dismissing these fields, nor is it about flipping the hierarchy and elevating other sciences or knowledges above Western sciences. Instead, it is about unlearning the socially sanctioned arrogance, exceptionalism, and ethnocentrism of Western sciences so that they can become more socially and ecologically accountable, and thereby more relevant and responsive to today’s pressing social and ecological challenges (Machado de Oliveira 2021). Note that this is not necessarily about the arrogance of individual scientists thinking they have all the answers, many Western-trained scientists have a commitment to skepticism in relation to their own work. However, this skepticism is not always applied to the general claim that Western science disciplines have privileged access to universal truths.

Although the current social context has in many ways prompted a process of reflexive examination in Western sciences, the impacts will be limited if it is only externally imposed. To meaningfully confront colonialism in their fields, Western scientists would need to commit to engaging in what Western sciences already encourage, which is to question their inherited assumptions about the world. Many scientists are still unaware of the ways that their work affects and is accountable to Indigenous Peoples and lands (Wong et al. 2020). Western-trained scientists would need to learn to extend the same curious, critical eye that they use in their research to their own fields of study and to interrupt the perceived naturalization and universalization of their disciplinary frameworks. This includes questioning the benevolence of their disciplines by naming the role of Western sciences in the historical and ongoing erasure, devaluation, and loss of Indigenous knowledge systems (McKinley 2013; Simpson 2004), examining Western sciences’ complicity in unethical, non-consensual experiments on Indigenous Peoples, and addressing the ways Western sciences continue to benefit from “access to Indigenous lands, knowledge, and lives” without consent (Liboiron 2021a, p. 876).

4) Confronting colonialism in Western sciences calls for recalibration and repair: Confronting colonialism in Western sciences means moving away from epistemic exceptionalism and toward epistemic humility, as well

as cultivating deeper forms of intellectual and relational rigour (Machado de Oliveira 2021; Stein 2021). By *intellectually rigorous*, we mean acknowledging the situated gifts and limitations of all knowledge systems, including one's own; interrupting the tendency to project the values and notions of validity from our own knowledge systems onto others as if these were universal; respecting the internal intellectual integrity of different knowledge systems; approaching others' worldviews with the same level of respect as we would like others to show toward our own, especially in the context of posing skeptical questions while also respecting that different communities have their own protocols around knowledge; and recognizing the limits of knowledge itself, including by holding space not just for the unknown but also the unknowable (Mika et al. 2020). By *relationally rigorous*, we mean upholding Indigenous rights, including those outlined in UNDRIP, relevant national laws, treaties, and policies, and Indigenous Peoples' own laws (Ignance et al. 2023); accepting responsibility for the harmful historical and ongoing colonial impacts that have resulted from many practices of Western scientific knowledge production; committing to material redress and relational repair for these impacts, including by supporting the resurgence of Indigenous sciences led by Indigenous scientists and communities, the repatriation of Indigenous data and biological samples (Liboiron 2021a), and the return and rematriation of Indigenous lands to Indigenous governance (Yellowhead Institute 2019); and orienting one's work toward ensuring the well-being of current and future generations of all human and other-than-human communities.

- 5) Confronting colonialism in Western sciences will be difficult, painful, and uncomfortable, and will require developing stamina for the long haul, but it is possible: Regardless of their specific field of study or their institution, confronting colonialism challenges settlers' inherited assumptions and perceived entitlements to ownership, to universal epistemic authority, to unrestricted autonomy, and to enjoy the accumulated intergenerational social, political, and economic benefits derived from a centuries-long settler colonial system. Those trained and socialized in Western sciences will need to develop the ability to honestly and self-reflexively examine the colonial patterns that are imprinted in themselves and their institutions without becoming overwhelmed or immobilized, demanding to be rescued from discomfort, or seeking quick fixes or absolution. This is only the first step in a lengthy, winding process of unlearning and undoing harm. This process is "not linear nor inevitable" but rather will require "intentionality, vigilance, and a commitment to concrete and sustained action", including a "full-scale re-evaluation of scientific practice and culture" (Chen et al. 2022, p. 19).

If this sounds challenging, that is because it is. It is especially challenging because when settlers first begin this work, they often are unaware of the many layers of com-

plexity involved, or just how deeply colonialism has shaped our institutions, our fields of study, and ourselves. As a result, people tend to overestimate their level of preparedness (thinking that their good intentions and basic understanding of colonialism are enough), and underestimate the depth and complexity of the work that is actually required (thinking that it is just a matter of expanding inclusion and access to existing institutions). However, in the face of both proliferating calls for accountability from students and social movements, and multiple complex social and ecological "wicked problems", there is a need to develop the capacities and the stamina to sustain this work over the long haul, especially when it becomes uncomfortable and difficult. We know that confronting colonialism in Western sciences is possible, as many Indigenous Peoples who trained in Western sciences have been doing this work for a long time.

We suggest that if Western-trained scientists cannot accept these basic starting points, then their efforts to confront colonialism in Western sciences and engage with Indigenous sciences may be read as tokenistic, extractive, and consumptive, and they will likely fail to interrupt ongoing colonial patterns of relationship. Together, these starting points suggest the need for Western sciences to go beyond engagements oriented by inclusion and toward engagements that support the resurgence of Indigenous sciences and the sovereignty and self-determination of Indigenous communities more generally. Such a shift would require Western sciences to unlearn their presumed exceptionalism and entitlement to epistemic authority and learn how to enact material and relational repair for the harm they have done.

However, our intention in sharing these lessons is not to try and make sure everyone agrees with them; we know they will be unsettling for many and can have a disorienting effect on those trained in Western science fields. Instead, we invite people to observe how different parts of themselves respond to these five starting points, including what these different parts are saying, thinking, and feeling (e.g., resistance, anger, frustration, defensiveness, despair, excitement, shame, etc.). We encourage people to let go of the desire for coherence and learn to hold space for these internal complexities, especially if these different responses conflict with one another, including those responses they might not be especially proud of. We also ask people to get curious and consider where these different responses are coming from (systemically and in relation to their personal histories, fears, and desires), and what they are learning by observing these responses. For instance, how might these responses impact your ability to develop respectful and reciprocal relations with Indigenous communities and collaborators? How might they impact your teaching practice, and the ways you frame, conduct, and mobilize your research? What are these responses teaching you about the difficult parts of this work, and about the work that you still need to do in this area to go deeper? We invite readers to sustain this curiosity about their responses as they proceed to the next section where we introduce the social cartography of Western sciences' approach to engagements with Indigenous sciences.

Western sciences' engagements with Indigenous sciences

In this section, we offer a social cartography that illustrates three different ways that Western sciences have approached engagements with Indigenous sciences. Social cartography is a social science methodology that invites people to sit with and identify the assumptions and implications of multiple understandings of a particular issue, without seeking coherence or universal answers (Andreotti et al. 2016; Suša and Andreotti 2019). The maps that result are not intended to be descriptive of “what is” (in representative ways), nor prescriptive of “what should be” (in ways that tell people what to do or how to think), but instead, invite people to work with and through complex topics and difficult conversations in generative and generous ways. In this way, the maps can be understood as diagnostic: making visible the limits and possibilities of existing theories and practices; making apparent the individual and collective work that remains to be done; and potentially opening up viable but previously unimaginable ways forward.

In the map that we offer, we have identified three primary ways that Western sciences have approached engagements with Indigenous sciences: *dismissive* (i.e., outright devaluing, pathologizing, and excluding Indigenous sciences, and asserting the universality and superiority of Western sciences); *inclusive* (i.e., conditionally engaging and including Indigenous sciences, largely within existing institutional structures and frames, and often in extractive and selective ways that assess the value of Indigenous sciences according to the extent to which they adhere to the norms of Western sciences); and *reparative* (i.e., committing to interrupt the presumed universality of Western sciences; enact restitution and repair for the harms done to Indigenous Peoples, lands, and sciences by Western sciences; and learn to develop more respectful and reciprocal relations with Indigenous Peoples, lands, and sciences). In addition to describing each approach, we consider the assumptions that ground each approach by mapping how each understands Western sciences, Indigenous sciences, truth/knowledge, and rigour, as well as how they understand the role of science in ecological unsustainability and colonial violence.

We suggest that *dismissive* engagements with Indigenous sciences are increasingly considered “behind the curve” or out of sync with current conversations. Thus, although this approach is still common, departments or individual researchers that continue to take this approach are likely to become or may already be challenged for doing so. Meanwhile, *inclusive* engagements are “on the curve”, particularly as calls for reconciliation, Indigenization, and decolonization have become more mainstream. This was made evident, for example, when the US government recently released formal guidance on “recognizing and including Indigenous knowledge in Federal research, policy, and decision making” (Daniel et al. 2022). Finally, *reparative* engagements are “ahead of the curve”, as they are only just emerging, which also means they are still experimental and their impacts and implications are not yet clear. We do not claim these three categories of Western sciences' engagement comprehensively describe all pos-

sible modes of engagement. However, they can serve as a starting point for more complex, nuanced, and accountable conversations about the challenges and possibilities of this work.

In Table 1, we summarize the orientation of each approach to engagement. We also offer extensive footnotes for those who wish to learn more about the scholarly literature that informed the creation of the cartography and the common patterns that it maps. We note that these footnotes are citations of a selection of scholarship that documents the patterns that we have mapped, rather than scholarship that exemplifies the mapped patterns. Recognizing that citational practices can either reproduce or interrupt academia's systemic favouring of the expertise of white, Western thinkers, these footnotes and our citations for the paper overall reflect our engagements with the contributions of both Indigenous and non-Indigenous thinkers to this debate. At the same time, we emphasize that citation alone is insufficient for interrupting the colonial politics of knowledge. We recommend that readers engage with the work of the Civic Laboratory for Environmental Action Research on the complex politics of citation.

We note that alongside this map of Western sciences' engagements with Indigenous sciences, it would be important to also consider a parallel cartography of Indigenous sciences' engagements with Western sciences, and that these engagements are characterized by different power relations. Although we do not offer that cartography here, due to both space restraints and a recognition that this is work that should be led by Indigenous Peoples, we note that Indigenous scientists have engaged in multiple different strategies to interrupt settler colonialism in Western sciences and assert their intellectual and research sovereignty (Hird et al. 2023; Hudson et al. 2023; Leonard et al. 2023), including by: decentering Western sciences and centering Indigenous sciences (e.g., Hernandez et al. 2022); creating guidance materials to support more ethical engagements with Indigenous knowledges (e.g., Kūlana Noi'i Working Group 2021; Daniel et al. 2022; Hird et al. 2023); claiming space within colonial institutions to interrupt settler colonialism in Western sciences and redirect institutional resources in the service of Indigenous science, sovereignty, and resurgence (McAllister et al. 2022; Hird et al. 2023); taking an anticolonial approach to science that directly challenges perceived settler entitlements to Indigenous lands and knowledges, and that uses Western science “against itself”, without assuming it is ever “outside” of complicity in injustice (e.g., Liboiron 2021b); and enacting forms of epistemic pluralism (Andreotti et al. 2011; Reid et al. 2021).

By mapping approaches to engagement with Indigenous sciences by those trained in Western sciences, part of our intention is to encourage people to familiarize themselves with the social-historical conditions that have shaped these different approaches, and become aware of the common pitfalls that arise in more recent efforts to “listen to Indigenous voices” without also doing the challenging work of unlearning the systemic arrogance, presumed universalism, benevolence, and superiority of Western scientific perspective and worldviews (Spivak 1988).

Table 1. Three ways Western sciences engage Indigenous sciences.

	<i>Dismissive</i> (behind the curve)	<i>Inclusive</i> (on the curve)	<i>Reparative</i> (ahead of the curve)
Basic elements of engagement with Indigenous sciences	<ul style="list-style-type: none"> • <i>Pathologize</i> and denigrate the value and relevance of Indigenous sciences • <i>Dismiss</i> the importance of (engagements with) Indigenous knowledges¹ • <i>Deny</i> the role of Western sciences in the epistemicide of Indigenous knowledges • <i>Conflate</i> different kinds of critiques (e.g., flattening the distinctions between anti-science approaches and anti-colonial critiques of Western science) • Through ahistoricism, depoliticization, and ethnocentrism, claim the objectivity, universality, and exceptionalism of Western sciences² 	<ul style="list-style-type: none"> • <i>Recruit</i> more Indigenous students and faculty into (Western) science fields and programs¹⁰ • <i>Supplement</i> existing curricula with Indigenous authors and ideas (often in tokenistic, romanticized, decontextualized, depoliticized, appropriative, assimilative, consumptive, and (or) pan-Indigenous ways)¹¹ • <i>Include</i> at least one Indigenous person on each Western science research project • “<i>Verify</i>”/<i>confirm</i>” Indigenous sciences (and other knowledges) using Western sciences • <i>Indigenous sciences without Indigenous scientists</i>¹² • <i>Indigenous scientists without Indigenous sciences</i>¹³ 	<ul style="list-style-type: none"> • <i>Redistribute</i> resources to Indigenous scientists • <i>Interrupt</i> the harm caused by Western sciences, and enact material restitution and relational repair • <i>Support</i> the resurgence of Indigenous sciences¹⁹ • <i>Cultivate epistemic humility for equitable and accountable inter-epistemic dialogue</i>²⁰ • <i>Build capacity and stamina</i> for the long-haul, recognizing that (1) we will need to develop trust, respect, reciprocity, consent, and accountability; (2) Western-trained scientists will need to relinquish power and resources; (3) there will be tensions, conflicts, and incommensurabilities; (4) it will be difficult and entail failures; and (5) we are not there yet, we are just getting started²¹
Understanding of <i>Western sciences</i>	Western sciences are the apex of human knowledge, development, and progress; they are objective, universally valid, reliable, and relevant; they are the standard by which other knowledges should be measured ³	Western sciences are not the only knowledge systems, but they are the most valuable and universal; other knowledge systems can be included if they are not too disruptive or too different from Western sciences	Western sciences are just one of many valuable, situated knowledge systems; they have relevance for some contexts and questions, and not for others; they are accountable for addressing their historical and ongoing social and ecological impacts ²²
Understanding of <i>Indigenous sciences</i>	Indigenous sciences are not “real” science ⁴ ; Indigenous sciences are superstitions, myths, and from the past (an earlier stage of human evolution) ⁵ ; Indigenous sciences provide, at most, raw data for Western sciences	Indigenous sciences come from local stories and cultural traditions that can be extracted by Western scientists and integrated into Western science research so as to improve that research and make it more universal ¹⁴	Indigenous sciences, like Western sciences, come from specific contexts, and have their own ideas of rigour and relevance; Indigenous Peoples’ have sovereignty over their own sciences, data, and lands, which should be respected ²³
Understanding of <i>truth/knowledge</i>	There is a universal truth, which can be found through Western knowledges (especially sciences); validity should be determined by institutional experts ⁶	There is a universal truth that is determined by Western science, but Indigenous knowledges can be incorporated into that truth and make it more relevant and complete ¹⁵	Both Western and Indigenous knowledges (and more) are indispensable and insufficient; each knowledge has contextual relevance ²⁴ ; there is the known, unknown, and unknowable
Understanding of <i>rigour</i>	Intellectual rigour, as narrowly defined by Western sciences (objective, universal, Western scientific method) ⁷	Intellectual rigour (defined according to the terms of Western sciences), supplemented by relational rigour (defined as the conditional inclusion of difference in ways that sustain the status quo) ¹⁶	Both intellectual rigour (which includes respecting different ideas of rigour) and relational rigour (responsibility to humans, land, and other-than-human beings); recognize the complexity of balancing these ²⁵
Understanding of the role of science in <i>ecological unsustainability</i>	Western sciences are the best positioned to address ecological challenges; other knowledge traditions are useless and may be harmful distractions ⁸	Western sciences are best positioned to address ecological challenges, but Indigenous and other non-Western sciences can support and supplement them in useful ways ¹⁷	Western sciences have contributed to unsustainability; Western and Indigenous sciences (and more) are needed to address ecological challenges; to support Indigenous sciences, we must also respect Indigenous land sovereignty and rights ²⁶

Table 1. (concluded).

	<i>Dismissive</i> (behind the curve)	<i>Inclusive</i> (on the curve)	<i>Reparative</i> (ahead of the curve)
Understanding of the role of science in <i>colonialism</i>	Western science has nothing to do with colonialism, and it never has; the suggestion alone is treated as an insult ⁹	Western sciences played a role in colonialism, but we need to move on; colonialism is primarily about excluding Indigenous Peoples and knowledges ¹⁸	Western sciences have played a historical and ongoing role in colonialism (genocide, epistemicide, ecocide), and need to accept their responsibilities for material and relational repair ²⁷

¹Harding (1998), Higgins and Kim (2019).

²Castro and Collins (2021), Prescod-Weinstein (2020), TallBear (2013).

³Pickering (1992), Whitt (2009).

⁴Adas (1997), Harrison (2005).

⁵Rifkin (2017).

⁶Law (2015), Longino (1990).

⁷Skopec et al. (2021).

⁸Howitt and Suchet-Pearson (2006).

⁹Clayton (2020), McAllister et al. (2022).

¹⁰Carter (2020), Pidgeon (2016), Wong et al. (2020).

¹¹Jimmy and Andreotti (2021).

¹²Marsden et al. (2020), McKay and Grenz (2021).

¹³Castleden et al. (2015), Marker (2019).

¹⁴Ahenakew (2016), Fernández-Llamazares et al. (2021), Hernandez et al. (2022), Klenk et al. (2017), Liboiron (2021b), Ludwig (2016).

¹⁵Liboiron (2021a).

¹⁶Haynes and Patton (2019), MacMillan et al. (2019), Skovsmose (2009).

¹⁷Kadykalo et al. (2021), Reid et al. (2022), Reo et al. (2017).

¹⁸Dancy and Hodari (2022), Wiseman and Borden (2018).

¹⁹Cole and O’Riley (2017), Glanfield et al. (2020), TallBear (2019).

²⁰Eglash et al. (2020), Garcia-Olp et al. (2020), Johnson et al. (2016), Reid et al. (2021).

²¹Chen et al. (2022), Shotwell (2016), Stengers (2018).

²²Carter (2010), Machado de Oliveira (2021), Polanyi (1958).

²³Black (2021).

²⁴Ermine (2007), Haraway (1988), Higgins et al. (2019), Medin and Bang (2014).

²⁵Borden and Wiseman (2016), Kawa et al. (2021), Rosiek et al. (2020), Sylvestre et al. (2018).

²⁶Bratman and DeLince (2022), Fernández-Llamazares et al. (2021), Goldstein (2019), Higgins (2021), Kealiianakaoleohaililani and Giardina (2016), Muller et al. (2019).

²⁷Anthony-Stevens and Matsaw Jr. (2020), Bang et al. (2018), Harding (1993), McGee (2020).

For instance, it is generally more comfortable for settler scholars to (superficially) engage with Indigenous knowledges than it is for them to engage directly with their complicity in colonialism. When this engagement is oriented by a desire to avoid confronting how they are implicated in systemic harm, it can manifest as a “move to innocence” (Mawhinny 1998; Tuck and Yang 2012) that bypasses the necessary work of identifying and interrupting institutional infrastructures and individual investments in ongoing colonialism, repairing harm, and enacting restitution. This tends to lead to tokenistic, depoliticized, and extractive forms of engagement. As the *inclusive* engagement approach in the cartography describes, these kinds of extractive engagements indicate a desire to transcend complicity in harm without giving anything up (including perceived entitlements to land and epistemic authority). They are often also premised on the assumption that settlers are entitled to access Indigenous knowledges without developing relationships with Indigenous knowledge holders and communities grounded in trust, respect, reciprocity, and accountability, and without obtaining their consent (Whyte 2020).

An illustration of this dynamic comes from growing interest in the methodological approach of “Two-Eyed Seeing,” which derives from the Mi’kmaq term *Etuaptmunk*. Mi’kmaq Elder Albert Marshall describes “Two-Eyed Seeing” as “learning to see from one eye with the strengths of Indigenous knowledges and ways of knowing, and from the other eye with the strengths of mainstream knowledges and ways of knowing, and to use both these eyes together, for the benefit of all” (as cited in Reid et al. 2021). According to Nisga’a fisheries scientist Andrea Reid and colleagues (2021), this approach can support efforts to “move beyond the all-too-common dialogue of integrating, combining, or incorporating (commonly used as euphemisms for assimilating) other knowledges and ways of knowing into Western science, and instead build an ethic of knowledge co-existence and complementarity in knowledge generation” (p. 243). However, since first being introduced into scholarly conversations, Two-Eyed Seeing has been mobilized in many different ways by settlers and Indigenous peoples.

As Cree education scholar Cash Ahenakew (2023) suggests, “at its most generative, a Two-Eyed Seeing approach can serve as an interruption of the common desire for universal knowledge, and a reminder of the situated nature of all knowledges and ways of knowing (seeing)” (np.). Yet sometimes settlers approach Two-Eyed Seeing in ways that presume the homogeneity of different Indigenous knowledges (i.e., pan-Indigenism). Other settlers claim “they as individual knowers are engaged in Two-Eyed Seeing, rather than understanding it as a means of bringing together the insights of different knowledge communities, in ways that respect the value of those knowledges and the integrity of each” (Ahenakew 2023, np.).

Overall, in the context of Two-Eyed Seeing and other frameworks that invite engagements between Western and Indigenous knowledges, settlers tend to overemphasize the positive, “feel good” elements and fail to critically and self-reflexively engage with (and therefore, often reproduce) the

systemic power relationships, inequities, and complexities that characterize this interface.

Toward pluralizing the futures of science

From where we currently stand, in a context that is still deeply colonial, we might not yet be able to imagine what could become possible if those trained in Western sciences committed to the long-haul work of confronting colonialism in their fields and recalibrating those fields toward social and ecological responsibility, epistemic humility, and relational repair. We also recognize that not all Western-trained scientists will be interested in or committed to this work. Further, committing to this long-term and uncertain process might pose greater challenges in certain scientific fields compared to others due to the training and inherent assumptions ingrained in each discipline, as well as the perceived proximity between different knowledge systems. However, such observations should not diminish the depth of work ahead for all scientific fields, nor excuse anyone from accountability. Instead, they underscore how all sciences still have a long way to go (even those that self-identify as being “ahead of the curve”) and how many sciences continue to disavow their colonial entanglements and dismiss considerations of complicity as irrelevant or outside of the scope of their work.

If taken seriously, a sustained practice of situating all sciences within their socio-historical contexts and interrupting and repairing the colonial harms of Western science fields could lead to better science, and better scientists, in all disciplines (Prescod-Weinstein 2020; Reid et al. 2024; Wong et al. 2020). In this way, we might also begin to create the epistemic, material, and relational conditions and capacities that would enable scholars and knowledge holders to coordinate across multiple knowledge traditions in complementary ways that generate more ethical, equitable, and effective responses to complex social and ecological challenges (Feltes, Stacey and the T̓silhqot̓in National Government 2023; Whyte 2020).

The intention of these collaborations would not be to flatten or “resolve” the dissonances between knowledge systems to discover a more “universal” truth or arrive at a consensus. Such an approach would likely involve imposing one epistemic frame onto another, thereby assimilating one knowledge system into another—most likely, the assimilation of the less powerful knowledge system into the more powerful one. Instead, the intention would be to bring together the gifts of multiple knowledge systems in ways that centre our collective responsibilities and hold space for the complex co-existence of different priorities, worldviews, realities, and futurities. This is not just about respecting epistemic differences but also about positively valuing those differences, as well as humbly recognizing that *all* human knowledge is partial, situated, and limited.

As Māori philosopher of science education Georgina Turi Stewart (2023) writes, Western and Indigenous knowledges are “incommensurable forms of knowledge that can not be measured or compared by the same standard. This disjuncture is an opportunity for learning”. Several Indigenous epistemologies already have frameworks that value the co-

existence and potential complementarity of multiple knowledge systems instead of epistemic competition or assimilation (Andreotti et al. 2011; Reid et al. 2021). This is not to say that these epistemologies offer a universal formula for how to do this work, but they nonetheless indicate that it is possible to enact more horizontal, collaborative, and complementary relationships between knowledges than is currently practiced in most academic spaces. However, it will not be possible for Western-trained scientists to develop truly reciprocal relations if they refuse to give up their sense of universal epistemic authority and their perceived entitlement to access Indigenous knowledges and occupy Indigenous lands.

As we have reviewed in this article, there are many potential potholes along the path toward confronting colonialism in Western sciences, pluralizing the possible futures of science, and creating the conditions for ethical collaboration and epistemic complementarity that can enable the flourishing of all life on the planet. This path requires the surrendering of arrogance and exceptionalism. Further, because this work entails moving toward previously unimaginable possibilities, the path itself will be messy and emergent, rather than proceeding in a linear, straight line toward a fixed endpoint. Thus, rather than specific outcomes or destinations, our efforts to confront colonialism might focus on improving the quality of our relationships, ensuring the integrity of our collective learning and unlearning as we move, and allowing ourselves to be guided by our responsibilities to past, current, and future generations.

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