A POSTCOLONIAL DISCOURSE ANALYSIS OF
A TENTH GRADE SCIENCE CURRICULUM GUIDE

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Abstract

This study analyzed the construction of the concepts “science,” “scientific literacy,” and “Indigenous knowledges and ways of knowing” in *Science* 10, Saskatchewan’s tenth-grade school science curriculum guide. The postcolonial discourse analysis revealed several key presuppositions of modern Western (Eurocentric) discourses in the curriculum guide. The construction of “science” and “scientific literacy” revealed assumptions characteristic of modern Western science, while “Indigenous knowledges and ways of knowing” were paradoxically constructed as commensurable with but other than “science.” These findings demonstrate that Indigenous knowledges and ways of knowing are misunderstood in the curriculum guide. Moreover, the research suggests that thematic content may provide a better point of entry for the integration of Indigenous knowledges and ways of knowing into mainstream science programs than specific knowledge content (which may not necessarily cross cultural borders). This indicates the need to reconsider the development of multicultural science curricula across culturally diverse borders.

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CHAPTER ONE

INTRODUCTION

When I began this work in 2005, the Ministry of Education in Saskatchewan, Saskatchewan Learning, was in the midst of a complete renewal of science education curricula for grades six through twelve. The first installment of this project was *Science 10* (Saskatchewan Learning, 2005a), after which the junior and senior years science courses were to follow. This curriculum renewal is especially significant because it is the first re-write since the province has made explicit its commitment to the inclusion of Indigenous knowledges and heritage (what Saskatchewan Learning refers to in *Science 10* as "Aboriginal content and perspectives," "Indian and Métis content and perspectives," and "Indigenous knowledge and ways of knowing") across all curricula.

The commitment is laid out in Saskatchewan Education's *Core Curriculum Components and Initiatives* document (2000). The Aboriginal Education Provincial Advisory Committee explains:

> The Core Curriculum is recognized as a central feature of the provincial education system. It is a curriculum that creates spaces for Aboriginal voices, well beyond the Native Studies program. Integrating Aboriginal content and perspectives across the curriculum, within all subject areas is the goal for all students. (Saskatchewan Learning, 2005b, p. 4)

As one of the "broad initiatives that guide the selection of teaching materials, as well as instruction, in the classroom" (Saskatchewan Learning, 2000, p. 5), the *Core Curriculum* (2000) reads:

> It is an expectation that Indian and Métis content and perspectives be integrated into all programs related to the education of kindergarten to grade 12 students in Saskatchewan, whether or not there are Indian and Métis students in a particular classroom. (p. 6)

The inclusion of Indian and Métis content and perspectives is therefore regarded by Saskatchewan as important for *all* students.

Saskatchewan Learning (2005b) explains more specifically what is meant by the inclusion of Indigenous knowledge and ways of learning: "Integrating Aboriginal content and perspectives across the curriculum, within all subject areas," which "is the goal for all students" (p. 4), is mainly supported in terms of professional development among teachers as well as developing partnerships, resources, and policy with Aboriginal people. Saskatchewan Learning addresses the matter of curriculum actualization: "Teachers need support in theirs efforts to actualize the curriculum, provide mechanisms for charting progress, develop a comprehensive plan for language and culture programs, and to support the development of connections between programs in schools, communities, and the work place" (p. 18). Moreover, IKs are not to be included as an "add-on," as the Aboriginal Education Provincial Advisory Committee explains:

> Where schools are mistaken that Aboriginal content and perspectives are a curriculum 'add-on' and not an integrated goal, their understanding needs to be changed. Where there is a lack of voice for Aboriginal education leadership, ways to encourage dialogue such as around introduction of Aboriginal languages needs to be found. The educational community can support the building of teacher confidence by enabling their growth in knowledge. Universities are more convinced that Aboriginal content is important in all classes and this can build competence and sensitivity for teachers who are destined to teach an integrated curriculum. As a beginning point, education faculty and students might be "mandated" to take coursework in Aboriginal history and culture while the university as a whole could begin its work of incorporating Aboriginal content and perspectives into their courses of study. (Saskatchewan Learning, 2005b, p. 18)

While support for the inclusion of Aboriginal content and perspectives has appeared at the level of policy, it has yet to manifest at the level of curricula. Clearly this work still needs to be done. As the first installment of the first science curricula renewal in the province committed to the inclusion of "Aboriginal content and perspectives," *Science 10* could be an important document for the future of Aboriginal and multicultural (cross-cultural) education in western Canada.

Thesis Problem

In an effort to analyze the inclusion of Indigenous knowledges within *Science 10*, this study examines how the *Science 10* curriculum guide discursively constructs "Indigenous knowledge and ways of knowing" in relation to "science" and "scientific literacy." Thus, the problem this study is concerned with is as follows: *How does the way in which Science 10 constructs "science," "scientific literacy" and "Indigenous knowledge and ways of knowing" inform the inclusion of Indigenous knowledges?*

However, the challenge of integrating Indigenous knowledges and ways of knowing into curricula dominated by at least a century of Western content and perspectives is no simple task. Indeed, others have discussed the challenges of multicultural approaches to curriculum development (Aikenhead, 2001; 2002; Aikenhead & Huntley, 1999; Hadi-Tabassum, 2001; Stalney & Brickhouse, 2001). The words of Samina Hadi-Tabassum (2001) reflect the matter of *multicultural science* as it is used in this research:

> In contrast to the mainstream positions toward science, multicultural science promotes alternative ways of knowing or epistemologies that approach scientific knowledge from a first world and postcolonial framework that critically questions the empirical characteristics and ontological premise of Western science in order to emphasize the concept "epistemological pluralism." (p. 187-188)

As she explains, "the idea of multiple views of science and multiple ways of knowing science is a concept that describes the complexities of identity and discourse in our postmodern world" (188).

The focus and methodology of this thesis—a thematic discourse analysis emphasizing epistemological pluralism—is inspired by Kieran Egan's (2009) essay *Letting our presuppositions think for us*. Like Egan, I see the field of curriculum studies, and multicultural curriculum studies in particular, as unfortunately more like a marketplace in which people shout their wares, rather than an arena (or better yet, a classroom) where important questions are discussed and debated. And, like Egan, I believe that communication fails because of how little most curriculum writers seem aware of the presuppositions upon which their claims, beliefs, and arguments rest. However, in the case of multicultural curriculum development, I believe that communication fails because most curriculum writers lack awareness not just of *their* presuppositions but also (and perhaps more importantly) of the presuppositions upon which *others'* claims rest. As Marie Battiste and Sa'ke'j Henderson (2000) point out in the specific case of Eurocentrism, "Eurocentric legal and political thought has not confronted the problem of differing languages and worldviews" (p. 79). Thus the matter of multicultural curriculum development demands an awareness of the nature of culturally diverse perspectives. Awareness of culturally diverse perspectives, it should be noted, should not translate into the expectation that teachers be able to "walk in two worlds" (which few teachers can do), but rather into the expectation that teachers be(come) aware of the diversity of worldviews.

A central premise of this research is that the claims made by modern Western science (MWS) and Indigenous knowledges (IKs) are different (and sometimes incommensurable) because they rest on different (and sometimes incommensurable) presuppositions. The second chapter addresses certain incommensurabilities between MWS and IK to illustrate their diversity. While both in themselves are diverse, particularly the range of perspectives, histories, and knowledges that comprise Indigenous worldviews, for the purposes of this thesis, the two knowledge systems are understood to have in common a *scientific* nature, that is, a commitment to the *empirical* and *rational* (as I explain in greater depth in the literature review). Importantly, this is not to reduce either knowledge system to merely the "rational" and/or "empirical" with respect to their philosophical foundations; rather, it is just one attempt to find common ground upon which to construct multicultural science curricula. For example, the empiricism and rationality characteristically employed by MWS can be described as anthropocentric (human-centred), while the rationality and empiricism characteristic of IKs can be described as ecocentric (place-based). As such, the discourse analysis (DA) examines the discursive construction of "Aboriginal content and perspectives" in relation to "science" and "scientific literacy" in terms of the claims made and the (philosophical) presuppositions upon which those claims rest.

The intention of this analysis is to understand how the discursive construction of each of the above concepts informs, supports, or inhibits the possibility of a multicultural school science curriculum guide. Put differently, this research examines the relationship between *Science 10* and *cognitive imperialism*: "Cognitive imperialism, also known as cultural racism, is the imposition of one worldview on a people who have an alternative worldview, with the implication that the imposed worldview is superior to the alternative worldview" (Battiste, 2000, p. 192). Given the fact that Saskatchewan's secondary school student population includes a diversity of both Aboriginal and non-Aboriginal students, the question becomes, How does *Science 10* construct "science," "scientific literacy," and "Indigenous knowledge and ways of knowing" in relation to the broad worldviews of modern Western (MW; also Euro-American) knowledge and Indigenous knowledges, and is there a continued implication that the former worldview is superior to the latter?

I am interested in this question in order to help teachers and curriculum writers better understand the barriers and bridges inherent to the concept of multicultural science so that we can better develop multicultural school science curricula. Insofar as it identifies itself as a "multicultural" document, *Science 10* provides an excellent opportunity to assess the state of multicultural (science) curricula development in the internal neocolonial context of

Saskatchewan, Canada. Accordingly, is *Science 10* ethnocentric or culturally inclusive? Because *Science 10* represents a first step in the transition from an ethnocentric to a multicultural approach to school science, it may be relevant to the assessment and therefore development of multicultural curricula in other neocolonial contexts. The relevance of this work to other contexts demands that I acknowledge the limitations of this research.

Perhaps the most obvious limitation of this research has to do with the fact that the analysis examines only one curriculum guide, and so any generalizations that emerge from this research are the product of a single DA. As the methodology explains, there are relatively few examples of DA in the field of education, particularly in relation to curriculum documents and development. The DA itself is limited in terms of its linguistic analysis; instead, as in the continental tradition of DA, there is a poststructural emphasis on culture.

These limitations point to the need for further research into the possibilities of DA in the field of education, in general, and in relation to curriculum development, in particular. A complimentary study, for example, might conduct interviews with the writers, teachers, professors, etc. involved in the process of multicultural science curriculum development. How might the assumptions identified in *Science 10* be shared or opposed by those involved in curriculum development? In other words, could the process of identifying the assumptions that underlie curriculum development (as I do with the analysis of *Science 10*) facilitate future curriculum development across (sub)culturally diverse borders? Furthermore, given the cultural basis of languages, (how) could DA be relevant and/or useful in the analysis of authentically multicultural curricula?

Given the above mentioned limitations, the following two narratives from my personal experience have been included to add depth to my analysis of the data emerging from the DA of *Science 10*.

Two Narratives Demonstrating the Inclusion of "Aboriginal Content and Perspectives" in Curriculum Development

During my research, I was fortunate enough to be invited to sit as a member on a reference committee concerned with integrating Aboriginal content and perspectives in the soon-to-be piloted school science curricula for grades 6 to 9. The vetting committee consisted of teachers, academics, Elders, and one graduate student who were invited because of their involvement in the growing "field" of "Indigenous Knowledge."[1] My involvement in the vetting process resulted from the focus of this research, as well as work I have done for research projects concerning IK, one examining diverse Aboriginal education systems and learning for the Aboriginal Education Research Centre (AERC), and *Learning Indigenous science from place* (2008), a collaborative effort funded by the Canadian Council on Learning and headed by the First Nations University of Canada and AERC.

One of the first things we learned about our participation in the vetting process was that the learning objectives of the curricula were already determined—a reality for which few of us were prepared. On our meeting day, our job was to identify possible IK "indicators" for the already-determined MWS-based learning objectives. We were asked to identify indicators consistent with IK for such phenomena as cell division and mitosis, modern atomic theory, electromagnetic technologies, as well as the characteristics of series and parallel circuits, to name just a few. In a very short amount of time, it became apparent that the person/s responsible for

[1] Here, I designate IK as a "field" to draw attention to the increased interest it has received in postsecondary and research institutions and academic literature.

determining the objectives of the curricula—the person/s responsible for integrating the two ethnosciences—knew little to nothing of IK.

As the supposed experts of IK, in only a few short hours, we were expected to translate specific learning objectives derived from an exclusively modern Western scientific paradigm into Indigenous equivalents. It should be noted that while several objectives may have been relevant to an Indigenous context, it is inappropriate to assume that MWS translates into IK.

In another instance, I was approached by a high school science teacher involved in developing curricular resources concerning the inclusion of "Aboriginal content and perspectives" in *Science 10*. After asking me the focus of my thesis (to which I replied, "Analyzing the inclusion of Aboriginal content and perspectives in *Science 10*"), the teacher said, "Oh yeah, we did that." More specifically, s/he was referring to a resource guide that adapts the objectives of *Science 10* to the "the Snake Game." The teacher then said, "After learning the science, students can apply it [the science] to the Snake Game." Again, the principles of MWS are assumed to cross cultural borders and be not just applicable but relevant to Indigenous contexts. In this case, the objectives of *Science 10* are assumed to be relevant to the Snake game. (The proportion of Indigenous societies that played the Snake Game is altogether another matter.)

In both cases, Indigenous knowledges ("Aboriginal content and perspectives") are included (or *allowed* to be included) to the extent that they reflect the objectives of the curricula (which at first glance appear to be constructed according to the theory of MWS). The assumption that the inclusion of Aboriginal content and perspectives can be achieved in the application of MWS to Indigenous contexts intimates that Indigenous knowledges and philosophies are misunderstood.

The rest of the chapters in this thesis can be summarized as follows. The second chapter addresses the literature relevant to the problem of multicultural school science curriculum development. The third chapter explains the methodology of this research, including my approach to DA and the criteria for curriculum evaluation. The fourth chapter focuses on the findings from my analysis of the inclusion of IK in *Science 10*. Lastly, the fifth chapter highlights key findings and my recommendations for the development of multicultural (cross-cultural) school science curricula in Canada.

CHAPTER TWO

LITERATURE REVIEW

The issue with which this thesis is concerned is the inclusion of Indigenous knowledges in *Science 10*. The problem situation of the thesis occurs at the cross-cultural intersection of the traditional discipline of academic science and the burgeoning field of multicultural science in relation to curriculum development in Saskatchewan, Canada. The intention of this section is to introduce the reader to the tensions inherent to crossing cultural borders in the process of developing and practicing multicultural school science curriculum.

Altogether, four subsections in this chapter address the key issues involved in multicultural school science curriculum development in Saskatchewan. The first subsection introduces the reader to the broader context of the problem, namely, the internal *neocolonial context* of the province. The second subsection defines *science* as multicultural practice in such a way that it broadly accommodates both the similarities and differences between modern Western science (MWS) and Indigenous knowledges (IKs). The third subsection explores the *ideology of preprofessional science training*—the (modern Western) ideology that produced the first science curriculum and that continues to dominate school science today. Lastly, the fourth subsection explains the nature of cross-cultural translatability and perhaps its greatest barrier, what Battiste and Henderson (2000) refer to as the *Eurocentric illusion of benign translatability*.

The Internal Neocolonial Context of Saskatchewan, Canada

In their article, *Toward a decolonizing pedagogy: Social justice reconsidered*, Tejeda, Espinoza and Gutierrez (2003) describe what many refer to in the United States as an *internal neocolonial context*. Internal neocolonial contexts have their "origins in the mutually reinforcing systems of colonial and capitalist domination and exploitation that enslaved Africans and dispossessed indigenous populations throughout the seventeenth, eighteenth, and nineteenth centuries" (p. 11). Given that all of Turtle Island was colonized into what many refer to as North America according to the same European-imperial model, this theorization is equally applicable to Saskatchewan, Canada.

Postcolonial scholars Tejeda, Espinoza, and Gutierrez (2003) explain the *internal neocolonial context* against which they struggle:

> We live in an internal neocolonial condition because we engage in colonial relations of domination and exploitation in the production and reproduction of our material existence and its cultural expression. […] Our colonial domination and oppression materialize in the here and now of the processes and practices of our everyday lives—especially those related to securing the basic necessities of life. […] We labor and relate to others in the production and reproduction of our social existence with the weight of a colonial and imperialist past squarely on our backs. It is within the circumstances inherited from that past that we reproduce the condition of our social existence and make our history. We are not, however, condemned to continue to making and remaking the condition of our existence according to the circumstances imposed by our past. (p. 18)

The authors characterize our contemporary context as *colonial* "because there continues to be a structured relationship of cultural, political, and economic domination and subordination between European whites on the one hand, and indigenous and nonwhite peoples on the other." They characterize it as *internal* "because the colonizing/dominant and colonized/subordinate populations coexist, are often socially integrated, and even share citizenship within the same national borders." Lastly, the authors define our context as *neo*-colonial because they believe "it is necessary to distinguish between the forms of domination, oppression, and exploitation of the internal colonialism of the seventeenth, eighteenth, and nineteenth centuries," on the one hand, "and the forms of domination, oppression, and exploitation that have characterized the internal colonialism of the twentieth and twenty-first centuries," on the other (p. 15). Importantly, internal neocolonial contexts are maintained not just by material or punitive force but also (and perhaps more importantly) by cognitive or ideological force.

Though imperialism may have at first been facilitated by militaristic and then economic might, it is now facilitated primarily by control over the means of representation. Ashcroft, Griffiths, and Tiffin (2000) explain how control of the means of representation confirmed the hegemony of modern empires:

> Ultimately, however, it was the control of the means of representation rather than the means of production that confirmed the hegemony of the European powers in their respective empires. Economic, political and military dominance enabled the dissemination of European ideas through the powerful agencies of education and publishing. But it was the power of imperial discourse rather than military or economic might that confirmed the hegemony of imperialism in the late nineteenth century. (p. 127)

Curriculum represents just one example of a discursive medium through which western knowledge systems, and the people that draw upon them, rationalize and normalize the internal colonial domination against which Indigenous and nonwhite peoples resist. Building on the postcolonial assertion of a direct and material relation between the political and social structures of colonialism and Western regimes of knowing and representation, Tejeda, Espinoza, and Gutierrez (2003) explain:

> It is an anticolonial and decolonizing theory and praxis that insists that colonial domination and its ideological frameworks operate and are reproduced in and through the curricular content and design, the instructional practices, the social organization of learning, and the forms of evaluation that inexorably sort and label students into enduring categories of success and failure of school. (pp. 20-21)

Left unchecked, such systems of knowledge and representation operate in academic contexts through concepts such as "history" (see Young, 2004) and "science" (see Harding, 1998; 2006) to colonize the mind into a modern (imperial; anthropocentric) worldview. It is for this reason that the representation of modern and Indigenous knowledge systems in *Science 10* constitutes the subject of analysis for this thesis. Accordingly, school science curricula is examined as a potential active participant in the re/production of internal neocolonial contexts.

The internal neocolonial context of Saskatchewan, Canada, is characterized by a hierarchically structured relationship between the colonizing/oppressive European whites, on the one hand, and the oppressed/subordinate Indigenous peoples (the descendants of the first humans living on Turtle Island) and their descendants, on the other. This relationship is largely informed by the education system in Canada. As Battiste (2000) explains, "the educational system, fostered by government and society, is the basis of Canadian cultural transmission" (p. 193). Drawing on Memmi and Freire, Battiste (2000) describes how modern public schooling, which "appears beneficial to all people and intrinsic to the progress and development of modern technological society […] has not been benign" (p. 194). She writes:

> Public schooling […] has been used as a means to perpetuate damaging myths about Aboriginal cultures, languages, beliefs, and ways of life. It has also established Western science as a dominant mode of thought that distrusts diversity and jeopardizes us all as we move into the next century. After nearly a century of public schooling for tribal peoples in Canada, the most serious problem with the current education system lies not in its failure to liberate the human potential among Aboriginal peoples but in its quest to limit thought to cognitive imperialistic policies and practices. This quest denies Aboriginal people access to and participation in the formulation of government policy, constrains the use and development of Aboriginal cultures in schools, and confines education to a narrowly scientific view of the world that threatens the global future (p. 194).

As such, Canadian schools are understood as sites of Eurocentric cultural transmission.

Citing the Royal Commission on Aboriginal Peoples, Battiste (2000) explains the colonial nature of "the current curriculum in Canada:"

> The 1996 report of the Royal Commission on Aboriginal Peoples […] explains how current educational policy is based on the false assumption of the cultural superiority of European worldviews, and […] attests to the need for the transformation of knowledge, curriculum, and schools. It recognizes that the current curriculum in Canada projects European knowledge as universal, normative, and ideal. It marginalizes or excludes Aboriginal cultures, voices, and ways of knowing. (p. 193)

Curriculum is thus understood to play a key role in the transmission of Eurocentric culture in an internal neocolonial context.

The theorization of Saskatchewan, Canada as an internal neocolonial context is useful for two reasons. First, it provides the broader context of more specific problem situation: the development of multicultural science curricula in the traditionally monocultural (Eurocentric) context of (academic) school science. Second, it lays down the foundation to explain some of the incommensurabilities of MWS and IK.

Multicultural Science in the Internal Neocolonial Context of Canada

In this section, I define "science" as it is understood in this thesis, that is, as *multi*cultural practice. More specifically, the definition of "science" advanced here is intended to accommodate the diversity of MWS and IKs without compromising their respective integrity. As such, *Science 10* is multicultural to the extent that it creates space for both MWS and IK. Indeed, *Science 10* (2005a) identifies itself as a multicultural document (p. 5). However, the matter of defining *multicultural science* requires that I first (re)define *science*.

In an effort to avoid complicity with the imperial character inherent to modern thought, knowledge, and language, this section defines "science" as cultural practice in a way that maintains the diversity of MWS and IKs. Broadly speaking, this requires interrupting the modern western (Eurocentric) systems of knowledge and representation that rationalize and normalize the colonization of Indigenous and nonwhite peoples and their knowledge systems. Western intellectual traditions typically associate the origins of (modern) science with (i) Greek philosophy and its abstract ideas, which radically advanced during (ii) the European Renaissance period of the 16^{th} and 17^{th} centuries (Aikenhead, 2006, p. 10). However, as I mean to demonstrate in this section, such foundations are not only imperial in their philosophical foundations but also historically inaccurate (because they acknowledge only one cultural tradition of knowledge of the natural world). In the instance of this research, I mean to interrupt imperial discourse as it occurs in the context of school science (curricula).

Taking Sandra Harding's (2006) lead, "following usage in multicultural and postcolonial science studies, as well as in the main tendencies in post-Kuhnian history, sociology, and ethnography of science," I use the term *science* "to mean any systematic empirical study of ourselves and the world around us" (p. 10). Harding elaborates:

> A knowledge system or set of inquiry practices will be referred to as a science if it is systematic and empirical, regardless of whether it is Western or non-Western, contemporary or ancient, obviously embedded in religious or other cultural beliefs or not apparently so. (p. 10)

Similarly, Aikenhead (2006) broadly defines "science" as "systematic knowledge of nature" (p. 7). Addressing its material and ontological dimensions, Ogawa (1995) defines a "science" as "a rational perceiving of reality," where "perceiving means both the action constructing the world and the construct of reality" (p. 588). Cajete (2000) offers perhaps "the most inclusive of its meanings, that is, as a story of the world and a practiced way of living it" (p. 14). Thus, for the purposes of this research, science is defined as any empirical and rational knowledge of and way of knowing (and living) in the world. Here, I must reiterate that "empirical" and "rational" are not to be limited to their Euro-Western definitions.

It is in this respect that I acknowledge the commensurability of MWS and IKs: both types of cultural knowledge traditions are scientific in the sense that they are empirical (observation-based) and rational (systematic; logical), though their respective empiricisms and rationalities are grounded in different (incommensurable) worldviews. As such, both knowledge systems are capable of arriving at the same truths (though this is not typically the case).

Consider the following: if a science is a rational and empirical knowledge of the world, then every culture that has ever lived (or lives to this day) must have had (or must have) a science. Food exemplifies this: Insofar as a culture has existed, it must have been able to acquire food, and therefore must have possessed a knowledge of nature, or a science. This was (and still is) as true of the Indigenous populations of the world as it was (and still is) for imperial societies. In other words, this definition of science is inherently *multicultural*.

Importantly, however, not all aspects of different sciences are commensurable. Rather, as Leroy Little Bear (2000) explains, “different ways of interpreting the world are manifest through different cultures, which are often in opposition to one another” (p. 77). Grounding “science” in the broader context of culture, Harding (2006) alludes to some of these incommensurabilities:

> Some cultures understand the dangers to health of smoking; others do not. Some understand how to manage chronic pain; others do not. Some understand the dangers to health of smoking; others do not. Some understand how to manage chronic pain; modern biomedicine has not until recently. Some can navigate effectively by the stars from Samoa to Australia; others would be totally lost if their global positioning system broke down. Some can get people to the moon; others cannot. Some can accurately and comprehensively grasp how cultural projects infuse their research practices; others cannot. (p. 11)

And I would add that some cultures have survived in their territories for millennia (e.g., Indigenous cultures) while others (e.g., modern cultures) have pushed the world to a threshold that will trigger runaway climate change if it is exceeded. The point to be made is that “to regard all of these different knowledge (or practice) systems as sciences is not to regard them as equally accurate, comprehensive, or useful with respect to any particular questions we might ask” (Harding, 2006, p. 11). In other words, different cultures’ sciences may be different in ways that inhibit understanding across cultural borders, or in ways that are simply incommensurable. An example of two such divergent scientific traditions is MWS and IK. Before addressing some of these points of divergence, it should be noted that (for the very reason of these incommensurabilities) it can be very difficult to approach IKs from a Western worldview. As Battiste and Henderson (2000) explain: “Eurocentric structures and methods of logical entailment and causality cannot unravel Indigenous knowledge or its processes of knowing" (p. 40).

Sandra Harding (2006) explains the ethnocentricity inherent in the matter of defining "science:" "The term itself is a Western one and can seem to commit yet one more case of Eurocentrism when I insist on using it to characterize knowledge systems not so conceptualized by their makers" (p. 11). Indigenous knowledges provide countless examples of such "sciences" not conceptualized as such by their makers. Aikenhead (2006) addresses the matter of self-definition with respect to Indigenous knowledges:

> Because an indigenous knowledge system is inseparable from the culture in which it evolved, some authors prefer the term *indigenous knowledge* to *indigenous science* (e.g., Semali & Kincheloe, 1999). The science education research literature, however, often identifies these indigenous knowledge systems by such phrases as Native science (Cajete, 2000), Aboriginal science (Christie, 1991), Mäori science (McKinley, 1996), and Yupiaq science (Kawagley, 1995), to name just a few. Each represents one of many indigenous sciences. (p. 9)

Aikenhead (2006), himself, "use[s] the term *indigenous science* because it seems more equivalent to the term *Western science* in the spirit of social inequality" (p. 9). I prefer the term Indigenous *knowledge* to Indigenous *science* because I focus on the incommensurabilities of MWS and IKs. However, in the spirit of equality, I have defined both knowledge systems as scientific, that is, as legitimately empirical and rational by virtue of the fact that they work (e.g., such knowledge systems contain the knowledge to feed their people). Ultimately, I recognize that whichever group holds the knowledge is the group most fit to define and name that knowledge.

Whether one prefers "Indigenous knowledge," "Native science," or other terms, the point to be made is that MWS and IKs are not just different, they are at times incommensurable. As such, Battiste and Henderson (2000) advise, when approaching IKs from a modern Western

(Eurocentric) perspective, “the best way to understand Indigenous knowledge is to be open to accepting different realities (however one uses this term)” (p. 40). Heeding this advice, and building on the mutually rational and empirical natures of MWS and IKs, in what follows I approach the difference between the two knowledge systems as *incommensurable* in the tradition of several scholars of both modern and Indigenous cultures and their respective scientific traditions.

In his novel *Ishmael*, Daniel Quinn (1995) distinguishes between two fundamental cultural types: *Takers* and *Leavers*. The distinction between Takers and Leavers is useful because, as Aikenhead notes, “the different knowledges systems of nature held by the Leavers and Takers have evolved over the years into 21st-century indigenous sciences and into 21st-century Western science, respectively” (p. 8). Quinn uses these terms to replace the more Eurocentric descriptors *civilized* and *primitive*, respectively. Aikenhead (2006) explains:

> Within Neolithic cultures a dramatic innovation appeared in Asia Minor about 10,000 years ago: The agricultural revolution began. Some groups bought into it, some did not. As a result, from that time onward, two fundamentally different types of cultures existed in the world. Each had its own stories that interrelated humans, the world, and the gods. These culture-based stories persist today in one form or another. (p. 8)

What Quinn finds significant about the distinction between these two cultural[2] types are the stories[3] they enact[4]:

> For the moment, all you have to know is that two fundamentally different stories have been enacted here during the lifetime of man. One began to be enacted here some two or three million years ago by the people we’ve agreed to call Leavers and is still being enacted by them today, as successfully as ever. The other began to be enacted here some ten or twelve thousand years ago by the people we’ve agreed to call Takers, and is apparently about to end in catastrophe. (p. 41)

[2] “A culture is a people enacting a story” (Quinn, 1995, p. 41).
[3] “A story is scenario interrelating man, the world, and the gods” (Quinn, 1995, p. 41).
[4] “To enact a story is to live so as to make the story a reality” (Quinn, 1995, p. 41).

The catastrophe to which Quinn (1995) refers is the global-environmental disaster that Taker culture has been perpetuating since the (modern) agricultural revolution that occurred in the Fertile Crescent of the Middle East (Asia Minor). As we now know, this catastrophe is the result of unsustainable levels of modern industrial production. By contrast, Indigenous knowledges sustained their peoples and their ecosystems until they were interrupted by the event known as Contact and the subsequent period of colonization. (And Indigenous knowledges continue to sustain their people and their ecosystems were they have not been interrupted by imperialism and colonization.) As Cajete (2000) explains, "Native science is a product of a different creative journey and a different history than that of Western science" (p. 14). This brings me to the first distinction between MWS and IK that I wish to highlight: IKs have more often proven themselves *sustainable* whereas modern sciences have proven themselves *unsustainable*. The divergent histories of IKs and MWS—as sustainable and unsustainable, respectively—becomes more apparent if we identify the two scientific traditions with their guiding stories. (Here, I mean to emphasize the storytelling dimension of "science," as I define it in this thesis, in this case, emphasizing Cajete's (2000) definition of science "as a story of the world and a practiced way of living it" (p. 14). Science-as-story is emphasized because I feel it helps elucidate the relationship between a culture's history and its orientation to the world.)

The Taker story to which Quinn refers is the story of modern progress (i.e., *human* progress). Foundational to the story of modern progress "is the belief that a rational subject can truly come to know objective reality and this knowledge can be used to further human progress towards, in the words of seventeenth century scientist Francis Bacon, 'the effecting of all things possible'" (Blades, 1997, 17). As Quinn (1995) puts it, the premise of the Taker story is "the world was made for man, and man was made to conquer and rule it" (p. 74). This story, as

Takers tell it to their children, began approximately ten thousand years ago with the (modern) agricultural revolution and intensified during the industrial revolution. For the very reason that progress is measured almost exclusively in terms of *human* progress, I refer to this broad orientation as *anthropocentric* (i.e., human-centred).

Conversely, the premise of Leaver stories is "man belongs to the world" (p. 240). As Quinn observes, "if you take the Leaver premise," which humans enacted during their first three million years of existence, "then creation goes on forever" (p. 240). Cajete (2000) explains how Indigenous peoples' origin stories orient them to place: "Knowing the origins of their people, their place, and the all-important things their place contains is considered essential orientation for a tribal person. A people's origin story maps and integrates the key relationships with all aspects of the landscape" (74). For this reason, IKs have been referred to as "place-based" (LISP, 2008). As such, I refer to IKs as being *ecocentric* in their orientation.

This marks the second notable distinction between MWS and IK: MWS and IK demonstrate incommensurable orientations with respect to the natural world. More specifically, MWS demonstrates an *anthropocentric* (*human-centred*) orientation to the world whereas IK demonstrates an *ecocentric* (*place-based*) orientation to the world. Endorsing Quinn's (1995) distinction between Takers and Leavers, Aikenhead (2006) summarizes the point:

> The Takers' cultural stories place humans above nature in hierarchical importance, so when Takers live their lives (i.e., when they enact their cultural stories), it is common sense for them to take from nature; after all, the world is a human life-support system designed to sustain human life. The Leavers' cultural stories, on the other hand, tend to place humans equal to or below nature in hierarchical importance, so when Leavers enact their cultural stories, it is common sense for them to leave nature or give back to nature in a way that disturbs nature as little as possible; after all, harmony with nature will sustain human life. (p. 8)

More succinctly, Battiste and Henderson (2000) observe that "the difference between Eurocentric and Indigenous thought lies in the perceived relationship between people and the natural world" (p. 24). These two differently orientations to the world have given rise to two parallel knowledges of and ways of knowing the world.

In the spirit of anthropologist Claude Lévi-Strauss, Knudtson and Suzuki (2001) describe the Scientific Mind and the Native Mind as *parallel*. Quoting Lévi Strauss (in italics), they write:

> In his book *The Savage Mind* […] Lévi-Strauss completely sidesteps Western society's long-standing tendency to prejudge the Native Mind […] as little more than a spiritually stunted cultural antecedent to the nobler, more clear-eyed vision of modern science. Rather, Lévi-Strauss refers to the worlds of the shaman and scientist as *two parallel modes of acquiring knowledge about the universe* that have managed to give birth independently to *two distinct though equally positive sciences.* In these two fundamentally different modes of thought, *nature is accessible to scientific enquiry: one [is] roughly adapted to that of perception and the imagination: the other at a remove from it*. (pp. 8-9)

Aikenhead (2006) elaborates:

> Indigenous sciences are guided by the fact that the physical universe is *mysterious* but can be survived if one uses *rational empirical means*. Western science is guided by the fact that the physical universe is *knowable* through *rational empirical means*. Both types of knowledge systems are guided by ontological facts, and both rely on empirical evidence gathered by experimentation and field studies. (p. 113)

As we can see, though both knowledge systems are empirical and rational, a key difference has to do with their respective intentions: MWS is concerned with *knowing* while IKs are concerned with *survival*.

Credited as "the father of science," Thales (624 BC-546 BC) is generally understood to be the first philosopher (in the West) to ask the question: what makes up the world? Since then (and quite possibly since before then), MWS and its philosophical antecedents have been overwhelmingly concerned with the "stuff" of the world. The modern Western (MW) concern with the nature of stuff is largely imperial. For example, in the last few hundred years, "the problems that have gotten to count as scientific are those for which expansionist Europe needed solutions" (Harding, 2006, p. 43) namely, the conversion of global resources into material wealth. Battiste and Henderson (2000) explain the Eurocentric (modern Western) stance towards the pursuit of such knowledge about the world: "In Eurocentric thought […] the world is a background against which the mind operates, and knowledge is regarded as information that originates outside humanity" (p. 23). As Battiste and Henderson explain:

> In attempting to bridge the gap between humanity and the natural world, European philosophers have asserted that something in the Eurocentric mind can "see" facts in the raw data of the natural world and can order those facts in ways that reproduce other facts. (p. 24)

According to contemporary dominant (MW) discourse, "science" is that something in the MW (Eurocentric) mind that allows people to identify facts in and of the world—by virtue of the experimental method and the scientific laboratory. Consider, for example, how Canadian legal, nutritional, and medical institutions depend almost exclusively on facts (and "facts" derived from facts) in order to draw conclusions, and therefore, by extension, depend on MWS. As such, I refer to the knowledge of MWS as theoretical or abstract in the sense that it is concerned with the idea of the composition of the world.

Conversely, IKs can be described as practical, relational, or lived. Cajete (2000) writes that IKs are guided by "one of the oldest ecological principles practiced by Indigenous people all over the world," which is, "if you depend upon a place for your livelihood, you have to take care of that place or suffer the consequences" (p. 79). As Cajete explains, this was "a lesson learned and relearned by many generations over time. As a result of those hard-earned lessons, ecological principles have been incorporated as metaphysical as well as practical rules for human conduct" (p. 79). IKs are therefore practical in the sense that they are concerned with survival (that is, the knowledge to live sustainably). For the sake of comparing the forms of the two knowledge systems, IKs could be (crudely) described as being preoccupied with the question of how to establish and develop a sustainable lifestyle with the environment from which it emerges.

Thus, the third distinction drawn between these two rational and empirical ethnosciences has to do with the divergent forms that their respective knowledges take: MWS can be described as *theoretical*, or *abstract*, whereas IK can be described as *practical*, or *lived* (after all, what's more *practical* than survival?).

Not surprisingly, the two distinct cultural modes and their respective ethnosciences emerge from and reflect two different ontologies, which brings me to the fourth distinction between MWS and IK that I wish to address. On the one hand, MWS can be defined, in part, by its allegiance to a *closed* and *discontinuous*—discrete and dichotomous—binary ontology. On the other hand, Indigenous knowledge can be defined by its allegiance to an *open* and *continuous* ontology. According to Linda Waters (2004), it was this "ontology of binary, or discrete, dualist logic" that "operated as the colonial framework that deeply embedded Euro-American thought and language, and a Eurocentric perspective about Indigenous people, on the North American continent" (p. 97). As Waters (2004) explains, such nonunderstandings (hence misunderstandings) persist today:

> Euro-American institutions, including educational institutions, have placed many nonunderstandings about Indigenous people into the context of Euro-American-embraced conceptual categories. These categories signify a discrete (limited and bounded) binary dualist worldview. This worldview continues to operate as a template into which all Euro-American interpretations of Indigenous thought and being are recorded […]. Moreover, the Euro-American binary system of dualist thought empowered and facilitated the misinterpretations of the Indigenous nondiscrete binary dualist worldview; many of these misinterpretations remain active in contemporary scholarship. (p. 98)

The dichotomous modern ontology cannot therefore accommodate the "non-discreteness" of Indigenous ontologies without first acknowledging that there is some incommensurability.

Addressing the ontological incommensurability of MWS and IK from a modern Western perspective requires addressing the self-styled universality of MWS. Harding (1998; 2006) approaches the assumed universalism of MWS in her *unity of science thesis*: "According to the unity argument, there is one world, one and only one possible true account of it, and one unique science that can capture that one truth most accurately reflecting nature's own order" (p. 121). However, as Harding explains, "less visible in most articulations of the unity thesis is a fourth assumption: there is just one group of humans, one cultural model of the ideal human, to whom nature's true order could become evident" (p. 121). This is simply not the case; there are multiple interpretations of the world—as many interpretations, I would wager, as there are distinct worldviews. To make the point, for example, Indigenous ontologies understand "nature," "culture," and "science" differently than modern ontologies, which is to say, incommensurably.

In particular, the divergent ethnosciences' ontologies can be demonstrated in their respective expressions of the relationship between culture and nature (or in the absence of a distinction between the two). Sandra Harding explains:

> Deciding which features of humans and the world around us are a consequence of nature and which are created by culture has been a controversial issue in the West since the emergence of modern sciences. Of course, the issue has far older origins, but modern sciences seem to provide compelling evidence of just where the boundary between nature and culture is to be found. (p. 7)

The MW assumption of a *boundary* between nature and culture demonstrates the closed and discontinuous ontology of MWS. As Sandra Harding (2006) explains, this distinction does not necessarily cross cultural borders:

> To be sure, it has remained unsettling to see that other cultures have defined similar boundaries differently—for example, as the raw and the cooked or the domesticated and the wild. These contrasting ontologies are by no means restricted to premodern knowledge systems; rather, they have shaped modern scientific research in the very same fields in which Western scientists study nature. (p. 7)

Indeed, as Battiste and Henderson (2000) explain, "Indigenous peoples do not view humanity as separate from the natural world" (p. 24). That is, IKs do not identify "nature" and "culture" according to a closed and discontinuous binary ontology (i.e., as separate entities).

I believe the idea of *place* best represents what I crudely term (for the sake of comparison) the collapse of the nature – culture binary. For example, Gregory Cajete (2000) demonstrates how "nature," "culture," and "science" are collapsed into the concept of *place*:

> Native science is a story, an explanation of the ways of nature and the sources of life, embedded in the guiding stories of a people and the language and way of life that convey their stories. Indigenous people are people of *place*, and the nature of *place* is embedded in their language. The physical, cognitive, and emotional orientation of a people is a kind of a map they carry in their heads and transfer from generation to generation. This map is multidimensional and reflects the spiritual as well as the mythic geography of a people. (p. 74; emphasis added)

Similarly, Battiste and Henderson (2000) explain that "Indigenous peoples' worldviews are cognitive maps of particular ecosystems" (p. 40). The 2008 Saskatchewan report *Learning Indigenous science from place* explains that the Indigenous concept of *place* is difficult to articulate in Western languages (e.g., English). The report's literature review identifies five aspects important to the concept of place: place is *multidimensional*, *relational*, *experiential*, *local*, and *land-based* (p. 26 - 30). Quoting Edward S. Casey (in Feld, Stevens, & Basso, 1996), the report explains: "*Places* not only *are*, they *happen*" (p. 26). In other words, the Indigenous concept of *place* is better understood as a *verb* than it is as a *noun*. This is consistent with Battiste and Henderson (2000), who explain that Eurocentric thought and methodologies "derive from a noun-centred language system, and they are ineffective in verb-centered Indigenous language systems" (p. 40). The point to be made is that modern ontology and the *dichotomization* of nature and culture is incommensurable with Indigenous (i.e., place-based) ontology.

So far, this subsection has suggested the incommensurability of MWS and IK in terms of the two ethnosciences' divergent histories, politics, epistemologies, and ontologies (as well as languages). Indigenous knowledges are more likely to emerge from and reflect a sustainable history, an ecocentric political orientation with respect to the natural world, a practice-based epistemology, and an open and continuous ontology. MWS emerges from an unsustainable history, an anthropocentric political orientation with respect to the natural world, a theory-based epistemology, and a dichotomous binary ontology. To reiterate the point, when approaching IK from a modern Western (Eurocentric) perspective, "the best way to understand Indigenous knowledge is to be open to accepting different realities (however one uses this term)" (Battiste & Henderson, 2000, p. 40). Similarly, in her report on the protection of the heritage of Indigenous knowledge, Erica-Irene Daes writes that IK is "a complete knowledge system with its own concepts of epistemology, philosophy, and scientific and logical validity" (quoted in Battiste & Henderson, 2000, p. 41). In conclusion, *I believe that understanding and respecting Indigenous knowledge and ways of knowing* from a modern Western perspective *begins with understanding and respecting their differences.*

The Ideology of Preprofessional Science Training and the School Science Curriculum

This section builds on the previous discussion of the differences between MWS and IK, in order to explore how MWS has dominated school science, or in other words, how science has been understood and taught in schools. This section explains the present ideological premise of school science, namely, the production of little scientist through preprofessional training. As I have suggested, a key presupposition of this thesis is that *any perspective* on school science is culturally mediated (ideologically and politically speaking) by being based within a particular worldview or worldviews. As Aikenhead (2006) notes, any perspective on school science, whether it is humanistic, scientific, or multicultural, conveys an ideological point of view (p. 4). Reflecting on "the tension between educational soundness and political reality," Aikenhead advises, "we must never forget that curriculum decisions […] are first and foremost political decisions" (p. 4). School science, which "has traditionally attempted to prepare students for the next level of science courses by focusing on intellectual knowledge acquisition," (p. 1) reflects an ideology that favors and privileges MWS. Aikenhead elaborates:

> The traditional science curriculum advocates canonical science content and habits of mind (i.e., thinking and believing like a scientist). This scientist-oriented approach assumes that "science" in "school science" has the same narrow meaning as it has in, for example, "the American Association for the Advancement of Science." (p. 1)

The American Association for the Advancement of Science (AAAS) defines science according to the tradition of academic science, which is based in MWS. Furthermore, "science" in "scientific literacy" is traditionally assumed to have the same narrow meaning as it has in the AAAS.

Henry Bauer (1992) similarly writes that "widely publicized surveys" of scientific literacy "are based on the notion that scientific literacy has three components: the substantive concepts within science; the nature of scientific activity; and the role of science in society and culture" (p. 2). Furthermore, scientific literacy is often described as the degree to which someone is familiar with the general consensus of what the modern Western "scientific community" on what are deemed "scientific matters" (Bauer, 1992, p. 2-7). We can therefore say that the dominant conception of scientific literacy requires students to acquire the theory, practice, and story of MWS (as approached in the previous section). As such, a key premise of the dominant conception of scientific literacy is that school science reflects (or can reflect) "real world" science (i.e., MWS).

Aikenhead (2006) directs us to the broader history of school science in an attempt to understand the ideology that dominates contemporary school science:

> The ideology of today's science curriculum is easily understood when placed in the historical context of its 19th-century origin, which occurred at a specific time within the evolution of science itself. Thus the historical processes and cultural conventions responsible for humanistic perspectives in school science are necessarily nested within

> the history of the science curriculum in general, which itself is nested within the history of science in the Western world. (p. 7)

Aikenhead (2006) traces the first school science curriculum to the year 1867 and the British Association of the Advancement of Science (BAAS):

> The BAAS approved its "Scientific Education in Schools" report in 1867 (Layton, 1981). The BAAS promoted an ideology of "pure science," serving a self-interest in gaining members for the association and in obtaining research funds for those members. […] As a result, English education reformers in 1867 produced a science curriculum for secondary schools that marginalized practical utility and eschewed utilitarian issues and values related to everyday life. Instead this curriculum reflected the BAAS's newly achieved divide between science and technology and, at the same time, it reinforced social-class ideologies that favored the elite upper class. (p. 13)

As Aikenhead notes, these ideologies became the status quo for the science curriculum and have not changed despite what Ziman (1995) refers to as the "collectivization" of science during the 20th century into private interest "research and development."

Aikenhead (2006) and others (e.g., DeBoer, 1991; Frederick, 1991; Millar & Osborne, 1998) refer to this phenomenon or ideology as "the pipeline," the "ultimate purpose" of which "has been to funnel capable students into science and engineering degree programs" (p. 1). The pipeline ideology "is an elite scientist-oriented view aimed at marshaling 'the best and brightest' through the pipeline, *an ideology of preprofessional training*" (Aikenhead, 2006, p. 4; emphasis added). Both elite and non-elite science students are united in the pursuit of "the scientific habit of mind" which is assumed to be "the principal benefit resulting from scientific training" (Layton, 1981, p. 194; quoted in Aikenhead, 2006, p. 13). The pipeline is rationalized "as serving two main purposes" for "non-elite" science students: "their need to understand science well enough to appreciate its national importance, and their need to be literate enough to receive scientific messages expressed by scientific experts" (Aikenhead, 2006, p. 1). In other words, non-elite students are encouraged to learn the theory, practice, and story of MWS so that they may support MWS and its institutions. In practice, this means supporting science research and industry as taxpaying consumers, which maintains the hallmark hierarchical dominance (elitism) of the Western academy. Thus the pipeline prescribes one of two roles for students on the basis of academic merit, either *directly* as a (MWS) scientist or *indirectly* as a taxpaying consumer of industries that depend on research and development.

Most high school students, however, pursue career goals outside the pipeline and so training to be a scientist appeals to very few students. As such, most students feel uncomfortable in its scientist-oriented focus and, as a result, many students "would prefer a science education for everyday life" (Aikenhead, 2006. p. 1). Despite its irrelevance to most students, the ideology of preprofessional training will challenge any attempt to reform school science into a subject that embraces a humanistic perspective" (Aikenhead, 2006, p. 14), not to mention an Indigenous perspective.

This alludes to the imperial implications of teaching a scientific habit of mind based on the theory, practice, and story of MWS: "The goal of conventional science teaching has been to transmit to students knowledge, skills, and values of the scientific community. This content conveys a particular Eurocentric world view because science is a subculture of Western (Euro-American) culture" (Aikenhead & Huntley, 1999, p. 159). Those students who fail to identify with a Western (scientific) worldview face a potentially marginalizing cross-cultural experience when they study Western science (Aikenhead, 1996, 1997; Aikenhead & Huntley, 1999; Ogawa, 1995). Furthermore, "to transmit a Western scientific world view to these students amounts to cultural assimilation and tends to marginalize and even oppress many students" (Aikenhead & Huntley, p. 159). And so it is that the pursuit of "scientific literacy" under the ideology of preprofessional science training is a vehicle for modern Western (Eurocentric) cultural assimilation. Here we begin to see the links between school science and the ideology of preprofessional science training, on the one hand, and ecological and cultural imperialism, on the other.

Cognitive Imperialism in the Context of Multicultural School Science

This section addresses what I believe is the greatest barrier to the development of multicultural curriculum in the context of school science, what Battiste and Henderson (2000) refer to as the Eurocentric illusion of benign translatability. Moreover, the assumption that Eurocentric (MW) thought is universally translatable not only confounds the possibility of culturally inclusive science programming, but also facilitates cognitive imperialism.

Whether or not it is their intention, most attempts to "bridge" MWS and IK result in unfair comparisons of the two knowledge systems because the different ethnosciences are typically approached from one cultural perspective. In the internal neocolonial context of Saskatchewan, and Canada more broadly, that perspective is typically MW (Eurocentric). MW (Eurocentric) knowledge systems wrongly assume universal translatability across cultural borders and universal relevance to cross-cultural contexts. Battiste and Henderson (2000) refer to this as the Eurocentric illusion of benign translatability. As Battiste and Henderson (2000) explain, "the illusion of benign translatability has a practical purpose: it maintains the legitimacy of the Eurocentric worldview and the illegitimacy of Indigenous worldviews" (Battiste & Henderson, 2000, p. 80). It is "a tool of assimilation and power" that "affirms the idea of a universal language and worldview, while it conceals the inequalities encoded in the dominant language and worldview" (p. 81) as well as in the institutions themselves that have guarded entry through the door of progress. In other words, the assumption of cross-cultural translatability maintains cognitive imperialism, "the hierarchical and patrimonial monologue that has been created by Eurocentrism. This is often referred to as 'the Eurocentric monologue' or as 'the voice of truth,' as 'progress,' and as 'historical accountability'" (p. 13).

In the instance of multicultural curriculum development, the Eurocentric illusion of benign translatability occurs in the assumption that MWS (or science constructed in the image of MWS) is universal or, put differently, applicable and relevant across culturally diverse borders. This occurs when Euro-Canadian curriculum writers are mandated to include IKs but have no experience, knowledge, and/or relations with Aboriginal peoples, or seeming tools to address this problem. This could be a result of the double standard that requires Indigenous scholars to be familiar with modern worldviews, but does not require Euro-Canadian scholars to be familiar with Indigenous worldviews. Indeed, "the existing curriculum has given Aboriginal people new knowledge to help them participate in Canadian society, but it has not empowered Aboriginal identity by promoting an understanding of Aboriginal worldviews, languages, and knowledges" (Battiste, 2000, p. 192). Moreover, "most public schools in Canada today do not have coherent plans about how teachers and students can know Aboriginal thought and apply it in current educational processes" (p. 192). This is not to lay blame with any individual or any organization but rather to illustrate the problems inherent to understanding (as it relates to developing) multicultural curriculum.

The matter of developing culturally inclusive curricula therefore requires that MW thought reevaluate the matter of cross-cultural translatability because, as Battiste and Henderson (2000) explain, Eurocentric thought may be wrong to assume that culturally diverse worldviews are translatable:

> Eurocentric legal and political thought has not confronted the problem of differing languages and worldviews. […] The intercultural conflict between worldviews extends beyond questions of linguistic relativity and cultural pluralism, however, to the question

> of translatability. The traditional Eurocentric response is that worldviews can be translated. Yet, there are indications that this may not be true. (p. 79)

I believe Battiste and Henderson are correct: modern and Indigenous worldviews are not translatable because they are different in ontological and epistemological ways that inhibit full understanding across worldviews (i.e., in ways that are or may be incommensurable). For this reason, the development of multicultural (science) curricula must create space for the development of knowledges about nature, ecologies, and universe, as well as human and social encounters, that come from very different ontological and epistemological foundations which may not be entirely (or mostly) translatable.

In summary, the Eurocentric illusion of benign translatability explains how school science advances cognitive imperialism: the assumption of modern scientific universality cannot help but construct all other knowledges of the world as inferior by virtue of their inescapable differences.

Literature Review Summary

To reiterate, the intention of this chapter is to introduce the reader to the tensions inherent to multicultural school science curriculum development in the internal neocolonial context of Saskatchewan, Canada. These include 1) the broader context of internal neocolonialism, 2) a definition of *science* as (multi) cultural practice, 3) the dominant ideology of school science (the ideology of preprofessional science training), and 4) an understanding of cognitive imperialism in the context of school science. Perhaps the greatest barrier to authentically multicultural education is the ethnocentric assumption that a culture's knowledge is not only universally legitimate but also universally applicable (i.e., across cultural borders).

Tejeda, Espinoza, and Gutierrez' (2003) theorization of our context as *internal neocolonial* is important because it draws attention to the cognitive and ideological forces that sustain the material domination, oppression, and exploitation of Indigenous peoples (e.g., curriculum). As Ashcroft, Griffiths, and Tiffin (2000) explain, control of the means of representation and the re/production of imperial discourse confirmed the hegemony of modern empires.

Drawing on postcolonial studies of science (Harding, 1998; 2006; Cajete, 2000b; Knudtson & Suzuki, 2001) and cultural studies of science and science education (Aikenhead 2006; Hadi-Tabassum, 2001; Ogawa, 1995), "science" is defined in this thesis as a culturally specific empirical and rational (systematic) knowledge of the natural world. Importantly, this definition of science acknowledges and accommodates important differences between MWS and IK. In this chapter, I examine these two knowledge systems in terms of their divergent histories, politics, epistemologies, and ontologies. I suggested that IKs are more likely to support sustainable, ecocentric, practical, and inclusive practice, while MWS has tended to support practices that are unsustainable, anthropocentric (human-centred), theoretical, and dichotomous. Because of these differences, it can be difficult to approach IKs from a modern Western (Eurocentric) perspective or worldview. For this reason, understanding IK from a MW perspective begins with understanding the important differences between the two ethnosciences.

Outdated as it may be, academic MWS provides the dominant model of science for school science, that is, as science is practiced in schools (Ziman, 1995). According to this model, science is presented as an objective and democratic production of knowledge. However, as Harding (2006) points out, the myths of modern Western scientific objectivity and democracy are precisely what best serve private (imperial) interests. Aikenhead's (2006) work is especially useful in understanding the dominant ideology of school science as preprofessional science training. Building on the insight that any perspective of school science reflects a culturally specific ideology, the ideology of preprofessional science training encourages students to acquire the (sub)culture of modern Western science—or the “scientists’ science.” Also known as the “pipeline,” the principal aim of this approach to science education is to identify capable students and funnel them into science-related programs and careers. Focusing narrowly on academic MWS, the ideology of science training operates as a vehicle of modern Western (Eurocentric) cultural transmission.

Perhaps the greatest barrier to multicultural school science is the ethnocentric assumption that MWS is universally legitimate and therefore applicable across cultural borders. In the broader context of Eurocentric thought, Battiste and Henderson (2000) refer to this assumption as the Eurocentric illusion of benign translatability. As the authors explain, the illusion of benign translatability facilitates cognitive imperialism.

It is with these considerations in mind that the *Science 10* curriculum guide is approached and analyzed in this research study, in order to examine the state of multicultural school science education in the internal neocolonial context of Saskatchewan, Canada.

CHAPTER THREE

METHODOLOGY

This chapter outlines the study's research methodology and methods in terms of its theoretical perspectives, methods of data analysis, and criteria for evaluation. The theoretical perspectives that inform the study's conception of "discourse" and discourse analysis (DA) include poststructuralism and postcolonialism. The methodology of research can be described as a thematic DA with a primary theme of multiculturalism. The data analysis uses criteria for evaluation that centre on the claims made about science, scientific literacy, and IKs, as well as the presuppositions upon which they rest, and the culturally specific discourses that inform their construction.

Theoretical Perspectives

The methodology of this research is informed primarily by postcolonial theory and to a lesser degree by poststructural theory. Postcolonial theory, which informs the discourse analysis, emerges from poststructural theory, which informs the concept of discourse.

The conception of discourse as it is used in this research is indebted to French poststructural theorist Michel Foucault, whose position is summarized by Ashcroft, Griffiths, and Tiffin (2000):

> Discourse, as Foucault theorizes it, is a system of statements within which the world can be known. It is the system by which dominant groups in society constitute the field of truth by imposing specific knowledges, disciplines and values upon dominated groups. As a social formation it works to constitute reality not only for the objects it appears to represent, but also for the subjects who form the community on which it depends. (p. 42)

Moreover, there are anonymous rules controlling what can and cannot be said within a given discourse and it is these rules that characterize the discourse. The discursive rules concerning what can and cannot be said include such things as the classification, ordering, and distribution of knowledge of the world; consequently, it is these rules that inform the analysis of the discourse (Ashcroft, Griffiths, & Tiffin, 2000, 71). In particular, this research is interested in the discursive rules that control what is deemed "scientific" in *Science 10*?

The DA of *Science 10* is grounded in postcolonial theory, which is indebted to poststructural theory (Willinsky, 1994; Young, 2004). As Robert Young (2004) explains, poststructural theory has been interested in "the relation of the enlightenment, its grand projects and universal truth-claims, to the history of European colonialism" (p. 41). Poststructural theory, in its various forms, is therefore useful because of the way in which it links enlightenment thought ("rationality") to colonialism. However, "post-colonialism has a far more certain intellectual and political agenda," as it is not "caught up in a poststructural indeterminacy of meaning or the resulting collapse of unifying meta-narratives" (Willinsky, 1994, p. 615). Postcolonial foci can be described as one particular trajectory for poststructural work because postcolonial thought takes the same questions and brings them to the study of colonial and postcolonial contexts. Borrowing from Mi'kmaw scholar Marie Battiste (2000), I "use the term 'postcolonial' to describe a symbolic strategy for shaping a desirable future, not an existing reality" (p. xix). Such a stance acknowledges "the colonial mentality and structures that still exist in all societies and nations and the neocolonial tendencies that resist decolonization in the contemporary world" (xix). As such, postcolonial efforts seek to contribute to the decolonization of thought and society (and, in this case, school science).

Postcolonial theories adopt the concept of discourse to examine how modern thought, which is understood as "the complex of signs and practices that organize social existence and social reproduction within colonial relationships" (Ashcroft, Griffiths, & Tiffin, 2000, p. 42), resists decolonization. Accordingly, the effort to include Aboriginal content and perspectives within *Science 10* (and Saskatchewan's school curricula in general) is recognized as an important and necessary decolonizing project. But just how well does *Science 10* accommodate Aboriginal content and perspectives?

An examination of the discourses within *Science 10* will suggest the degree to which it is inclusive and decolonizing and/or the ways in which it may perpetuate colonizing practices through the perpetuation of dominant MWS discourses and knowledges. Thus, the definition of discourse I employ "contains the question of why certain meanings are experienced as right at certain times while others are considered to be wrong, how these meanings considered correct are born, and how they come to prevail" (Lehtonen, 2000, p. 42). Based on these definitions and considerations of discourse, we can see the object of analysis beginning to take shape: What "specific knowledges" about the natural world are sanctioned in *Science 10* and how are they imposed? How does *Science 10* construct what is considered true (and thus false) about the natural world? And most importantly to this thesis, do the discourses enacted in and by *Science 10* allow or disallow the inclusion of Indigenous knowledges?

Since "the intentions of the analyst always guide the theory and method of [discourse analysis]" (Rogers, 2004, p. 3), and because the intentions of this analysis are aimed at decolonizing curricula, postcolonial theorizing is useful because of its potential to elucidate and thus politicize discourse. It is in the spirit of imagining and creating postcolonial societies (and a sustainable future) that "we can view the analysis of discourse as a political intervention intended to challenge certain discourses, even as it constitutes or reproduces others" (MacKenzie, 2006, p. 200). DA, however, is a somewhat ambiguous methodology that varies in its methods and applications, which requires that I identify the theoretical framework that informs how I intend to use DA. The next section briefly outlines the methodology of DA and locates my specific approach within that.

The Methodology of Discourse Analysis

Discourse analysis as a methodology can be broadly understood as having two distinct traditions, each associated with a different philosophical heritage. The first, *linguistic discourse analysis*, has roots in Anglo-American linguistics, while the second, *poststructural discourse analysis*, has roots in European (or continental) philosophical and cultural thought (MacLure, 2003).

Within each theoretical perspective there exists a wide range of approaches to DA. As Luke (1995; in MacLure, 2003) explains, one way of distinguishing the two orientations would be in terms of a distinction between a "macro" and a "micro" level focus (p. 182). While both dimensions are required of DA in general, poststructural DA tends to prioritize the "macro" level analyses of social formations and institutions, while linguistics DA tends to favour the "micro" level analyses of written and spoken texts. To this end, James Gee is well known for the distinction he draws between "big D" and "little d" discourses (see Rogers, 2004; Rogers, Malancharuvil-Berkes, Mosley, Hui, & O'Garro, 2005): "'Big D' Discourse refers both to language bits and to the cultural models that are associated with Discourses. […] 'Little d' discourse refers to the linguistic elements—the language bits—that connect with such [big D] Discourses" (Rogers, 2005, p. 370). That is, "macro" level analyses are primarily concerned with "big D" Discourses, and "micro" level analyses with "little d" discourses.

While certain understandings may transcend disciplinary boundaries (e.g., linguistic *and* poststructural discourse analysts have appealed to Foucault's considerations of discourse), Rebecca Rogers (2005) is instructive on the matter of D/discourse: "The important thing to keep in mind about Discourse (both big and little d) is that they are social and political and have histories of participation that are saturated by power relations" (p. 370). As Marcia McKenzie (2006) explains, "the aim of discourse analysis is not to uncover an objective reality, but to investigate how we construct objectivity, or sedimented power, through the discursive production of meaning" (p. 200). There have been efforts to bridge or transcend the "micro-macro" divide. For example, critical discourse analysis (CDA), a body of work emanating from the linguistic side of the divide, is one such attempt "to marry the 'bigger picture' offered by social theory with the technical sophistication of linguistic analysis, to produce an integrated approach to discourse" (MacLure, 2003, p. 186). CDA has been active in education (see Rogers, 2004, 2005 for literature reviews).

This being "a world of binary antagonisms," as MacLure (2003, p. 186) notes, poststructural analysts criticize linguistic DA "for failing to take account of such aspects of the 'bigger picture' – that is, the political, ideological, cultural and economic dimensions of communication" (p. 185). Conversely, linguistic analysts accuse poststructural DA "of lacking the linguistic resources for analysing texts and, therefore, of failing to anchor (and therefore validate) their descriptions of large-scale discourses with reference to the actualities of talk and writing in specific settings" (p. 186). That said, my concern with the linguistic specificities of DA lies with its accessibility, which of course depends on the audience as well as the analyst(s). In an interview with Kamler (1997), Threadgold (quoted in Rogers, 2004) explains how CDA can be problematic as a research methodology in education, given educators' lack of a linguistic background:

> When you do really detailed linguistic work on a text, you disable many of your readers. There are lots of readers who need to know about the power of critical discourse analysis, but if you do detailed linguistic work it means that only linguists have that text accessible to them. (p. xi)

Because I do not want to alienate my readers, and because I do not have an extensive linguistic background, the DA employed in this thesis takes a poststructural approach. Put differently, I am concerned with how "big D" Discourse (macro level discourse) sediments itself in school science curricula in the construction of articulations of "science," "scientific literacy," and "Indigenous knowledges."

While there exists a substantial body of work in education influenced by poststructural theory (MacLure, 2003), DA is not especially prolific in the analysis of curricula. Scott Farmer (2004) provides one local example in his master's thesis—a DA of a grade ten history curriculum. In the interest of deviating from the linguistic restraints of more linguistically-oriented forms of DA, I quote Rogers (2004), who explains how thematic analysis constitutes a valid form of critical DA in the context of education:

> Approaches to discourse analysis that avoid combining a model of grammatical and textual analysis (of whatever sort) with sociopolitical and critical theories of society and its institutions are not forms of critical discourse analysis. At the same time, there are many, especially in education, who combine aspects of sociopolitical and critical theory with rather general (usually thematic) analyses of language not rooted in any particular linguistic background or theory. Such work is a form of critical discourse analysis, although it may not always be referred to as such. (p. 20)

While "thematic analysis" might seem vague, poststructuralism requires no rigidly defined methods of DA. And while the lack of restraints afforded by poststructural analysis facilitates this DA, the focus inspired by postcolonial theory motivates it. Thematic analysis thus constitutes a "valid" form of DA in the context of education.

The primary theme of the analysis is *multicultural inclusivity*, by which I mean to ask if *Science 10* is inclusive of different cultures' knowledges and ways of knowing the world. In the literature review, I tried to make two points in particular with respect to the words *multicultural* and *science* in the context of this research, which are worth repeating at this point for the sake of clarity. First, I explained that *science* refers to an empirical and rational (logical; systematic) knowledge and way of knowing the (natural) world. Thus every culture that has existed has had, by the fact of its very existence, the ways of knowing and knowledge needed to survive their environment (or world). Second, I explained that *multicultural* refers to diverse, and sometimes incommensurable, culturally specific perspectives on the world (or "ethnosciences," if you like). Many of the presuppositions of MWS and IK, for example, are incommensurable. Building on these two foundational assumptions, and drawing upon postcolonial insights and critique, I examine *Science 10* for its inclusivity of diverse cultural perspectives, particularly Indigenous knowledges and ways of knowing. Samina Hadi-Tabassum (2001) is worth repeating, here, on the matter of *multicultural science* as it is used in this research:

> In contrast to the mainstream positions toward science, multicultural science promotes alternative ways of knowing or epistemologies that approach scientific knowledge from a first world and postcolonial framework that critically questions the empirical characteristics and ontological premise of Western science in order to emphasize the concept "epistemological pluralism." (p. 187-188)

In other words, I ask, is *Science 10* "epistemologically pluralistic?"

Focus of Analysis

The purpose of this research study is not just to address the inclusivity of *Science 10*, but also to identify how the construction of "science," "scientific literacy," and "Aboriginal content and perspectives" informs the inclusivity of *Science 10*, in general, and with respect to Indigenous knowledges and ways of knowing, in particular. Put differently, How does *Science 10* construct "science," "scientific literacy," and "Aboriginal content and perspectives" in relation to the broad worldviews of modern Western (Euro-American) knowledge and Indigenous knowledge, and is there a continued implication that the former worldview is superior to alternative worldviews? Which ethnoscience/s does *Science 10* encourage students to enact? The inclusivity of *Science*

10 will be examined in terms of the claims made about "science," "scientific literacy," and "Indigenous knowledge" and the presuppositions upon which they rest.

The methodology for this analysis was also inspired by Kieran Egan's (2009) essay, *Letting Our Presuppositions Think for Us*. This paper is an attempt to address "how ineffectually people typically engaged others' arguments" (para. 1) in the field of curriculum development. Egan's thesis is that "disagreements about presuppositions are usually the case when it comes to arguments or decision-making about the curriculum" (para. 3). As a result, conversations about curricula (development) are often rendered meaningless because claims are debated without addressing the presuppositions upon which they rest. As Egan (2009) explains, "part of the trouble seemed to be how little most writers seemed aware of their presuppositions" (para. 1). From my experience with multicultural science curriculum development (explained in two narratives in the first chapter), I would add that a large part of the trouble seems to be how little most writers seem aware of other cultures' presuppositions. As previously outlined, Eurocentric (modern) thought, for example, often mistakenly assumes its presuppositions to be universally applicable.

Since claims rest upon presuppositions, "it would be an absurd strategy to deal only with the claims and ignore the presuppositions, because it may well be that our disagreements are at the level of presuppositions" (Egan, 2009, para. 2). The intention of this DA is to tease out the *presuppositions* upon which the *claims* made of and about "science," "scientific literacy," and "Aboriginal content and perspectives " rest in order to identify possible barriers and bridges to the development of multicultural science curricula. The most central problem of this research has to do with the positioning of Indigenous knowledges with respect to "science." Addressing this problem, however, requires first examining the construction of "science" and, relatedly, “scientific literacy” in the curriculum guide, and then examining how such constructions inform the inclusion of IKs in *Science 10*.

In conclusion, the focus for the DA is as follows: How do the claims that construct “science,” “scientific literacy,” and “Aboriginal content and perspectives,” in *Science 10*, and the presuppositions upon which they rest, inform—support or contradict—the inclusion of Indigenous knowledges?

CHAPTER FOUR

DISCOURSE ANALYSIS OF THE INCLUSION OF INDIGENOUS KNOWLEDGES IN *SCIENCE 10*

This chapter takes up what I identify as the three most fundamental concepts with respect to multicultural science in *Science 10*, namely, “science,” “scientific literacy,” and “Indigenous knowledge and ways of knowing” (also in relation to the latter, “Aboriginal content and perspectives” and “Indian and Métis content and perspectives”). To reiterate, the intention of the analysis is to establish whether or not *Science 10* is “multicultural,” by which I mean inclusive of Indigenous knowledges (IKs). As mentioned in the methodology, the inclusivity of *Science 10* is examined in terms of the positioning of IKs relative to the concepts of science and scientific literacy. This requires that I first examine the construction of the concepts “science” and “scientific literacy” in *Science 10*. For example, are “science” and “scientific literacy” constructed according to ethnocentric or pluralistic definitions?

The methodology of the DA involves, first, identifying the claims according to which *Science 10* constructs each of these three concepts, and, second, examining the philosophical assumptions (presuppositions) underlying the construction of each concept. Thus the previous question can be revised to read: are the claims (and presuppositions) that construct “science” and “scientific literacy” ethnocentric or pluralistic? Because *Science 10* is an example of the current state of multicultural school science curricula development in the internal neocolonial context of Saskatchewan, this analysis hopes to expose some of the barriers and/or bridges—at the levels of claim and presupposition—facing the inclusion of IKs within school science programs and curricula. All of the quotations in this chapter are taken from the Saskatchewan Ministry of Education *Science 10* (2005) curriculum guide.

Science 10 and the Concept of Science

Reading over the *Science 10* curriculum guide for the first time, one can hardly be blamed for thinking that "science" is *singular*. The language of *Science 10* emphasizes the singular tense with respect to the various dimensions of science: "the nature of science" (p. 2); "the scope and character of science" (p. 3); "the development of science" (p. 3); "the history of science" (p. 3); "the focus of science" (p. 3); "the test of science" (p. 3); "the subject matter of science" (p. 3); "the role […] of science" (p. 4); "the context of science" (p. 18); "the processes of science" (p. 20); and "the lens of science" (p. 21). Obviously, multiple sciences cannot have a singular nature, scope, character, history, development, etc. The idea of *science as singular* would appear to contradict a commitment to "an inclusive science curriculum," which, as the curriculum guide states, "respects the variety of worldviews that various cultures use to understand and explain their relationships with the natural world" (p. 6). As we can see, *Science 10* supports the idea of many cultural worldviews, and yet of one science. If *Science 10* constructs "science" as singular, the question then becomes, *how* does a curriculum guide apparently committed to multicultural science construct science as singular?

The third page of the curriculum guide explains the aim of "science" according to *Science 10*: "the focus of science is on the development and verification of knowledge." Elsewhere, the curriculum guide reads, "science deals with the generating and ordering of conceptual knowledge" (p. 46); similarly, "scientific knowledge is generated by, and used for, asking questions concerning the natural world" (p. 61). To this end, "scientists write to inform, to persuade, to reflect, and to construct knowledge claims" (p. 18). The following paragraph from *Science 10* (about the "Nature of Science and Technology") explains more thoroughly how the curriculum guide understands "science" as "the development and verification of knowledge:"

> Science provides an ordered way of learning about the nature of things, based on observation, and evidence. Through science, we explore our environment, gather knowledge, and develop ideas that help us interpret and explain what we see. Scientific activity provides a conceptual and theoretical base that is used in predicting, interpreting, and explaining natural and technological phenomena. Science is driven by a combination of specific knowledge, theory, and experimentation. Science-based ideas are continually being tested, modified, and improved as new knowledge and explanations supersede existing knowledge and explanations. (p. 3)

As this quote demonstrates, *Science 10* constructs "science" as a specific and evolving body of knowledge and theory about the natural world (and not, say, as a practiced way of living in the natural world). Moreover, science is constructed as the means by which "we" cross the boundary separating us from "our environment." This orientation towards knowledge, as information existing in nature (i.e., knowledge as abstract/ed from nature), is characteristic of MWS. The following two paragraphs (which have been re-constructed from various Key Concepts in the guide) explain the theory and the practice of scientific knowledge production respectively.

The theory of knowledge production in *Science 10* can be summarized as measurement oriented toward the end of *prediction*. As the curriculum guide explains, "science searches for cause-effect relationships that enable predictions to be made" (p. 36; p. 76; p. 85). To begin with, "scientists use models to represent objects, events, or processes" (p. 33). More specifically, "models (physical, mathematical, or conceptual) are simplified representations of real phenomena that facilitate a better understanding of some scientific concepts or principles" (p. 54). Physical, mathematical, and conceptual models thus are understood to represent reality *quantitatively*. The assumption, here, is that "numbers can convey important information in science and may be used to express physical relationships in an abstract form" (p. 57). Two examples include "the use of scales to represent severity of weather events" (p. 76) and "the relative strengths of acids and bases" (p. 71). The predictive power of models, however, is limited by uncertainty. While "scientists strive for *accuracy* in measurements" (p. 79), they recognize that “all measurements are subject to uncertainty based on the limits of the measuring device” (p. 52; p. 79). Accounting for the uncertainty, science is understood to be able to calculate the probability of an event occurring: “Probability is the relative degree of certainty that can be assigned to certain events happening in a specified time interval or within a specific sequence of events” (p. 85). In other words, probability measures the predictive power of the science in question. Thus, because uncertainty is inherent to science, “science does not make absolute predictions such as a weather forecast” (p. 85). As these claims about the theory of knowledge production demonstrate, *Science 10* makes the assumption that scientific knowledge is (mathematically) abstracted from the natural world. Acquiring scientific knowledge, according to this scheme, is a matter of measurement.

The practice of scientific knowledge production in *Science 10* is the method by which to cross the nature/culture dichotomy and (soundly) acquire knowledge of “the nature of things.” According to *Science 10*, “the laboratory provides an optimal setting for motivating students while they experience the natural world through the lens of science” (p. 21). Experiencing the natural world, according to *Science 10*, begins with observation: “scientific knowledge is based on observation” (p. 49). Elsewhere, the guide reads: “Observing and describing, using our senses, are basic processes of science” (p. 61). Observations are then classified: “Classifying is a systematic procedure developed by humans to impose order on collections of objects or events” (p. 33). The data collected is then interpreted, which means finding patterns in the data that can lead to generalizations about the data (p. 33; p. 52; p. 69; p. 79). Hypotheses are then made based on the data: “Hypothesizing is stating a tentative generalization that may explain a large number of events and that may be tested experimentally” (p. 54; p. 69). Hypotheses are then tested experimentally: “Designing scientific experiments involves planning a series of data-gathering operations that will provide a basis for testing a hypothesis or answering a question" (p. 52; p. 65). Hypotheses are typically theorized in terms of the effect of one variable on another: "Variables are controlled in scientific experiments in order to determine the effect of changing one variable on another variable" (p. 52; p. 69). Conclusions are then inferred from the generalizations gleaned from research: "inferring is explaining an observation in terms of previous experience" (p. 61). The confirmed or rejected hypotheses are then contributed to the accumulated body of knowledge produced by science.

As the analysis reveals, *Science 10* makes several specific claims with respect to the intention, theory, and practice of science. Most notably, science is constructed as singular, in the sense that it has a single nature, scope, history, theory, practice, etc. More specifically, the claims that construct the intention of science argue that scientific knowledge is pursued for its own sake. The claims made with respect to the theory of (scientific) knowledge production assert that science represents the natural world through cause-effect relationships that are oriented towards the end of prediction. The claims made with respect to the practice of (scientific) knowledge production reflect the scientific experimental (laboratory) method. Upon closer inspection, however, it can be demonstrated that these claims rest upon foundations particular to MWS.

To begin with, the claim that the intention of science is to produce (or develop) knowledge of the world rests upon the presupposition that science is objective (disinterested). This assumption about the nature of scientific knowledge appears to indicate the "discourse of objectivity" characteristic of MWS (and MW contexts in general). As the literature review explains, all knowledges of the world (most sciences) are suited to some purpose. For example, every culture's scientific knowledge must, at least in part, be practically oriented towards the acquisition and preparation of food and water. Additionally, IKs tend to be specifically oriented towards the simultaneous preservation of culture and place.

The theory of scientific knowledge production, as it is presented in *Science 10*, makes the claim that scientific knowledge is a representation of "the nature of things." Relatedly, the experimental laboratory science suggests the means by which humans (scientists) access knowledge (in nature). According to this story of knowledge production, knowledge exists in "nature," separate from "culture," and "science" provides the means (vis-à-vis the experimental method) by which to access knowledge. The construction of "science" in *Science 10* rests upon the idea that nature and culture are separate entities and "science" is the means by which to cross the boundary separating the natural and cultural worlds. As explained in the literature review, the distinction between nature and culture is typical of MWS. Thus we can say that *Science 10* draws on the theory and practice of experimental MWS, in general, and the discourse of objectivity, in particular, in the construction of "science."

The point to be made from the analysis, however, is that the construction of "science" in *Science 10* not only is an outdated and outmoded premise of MWS, but also takes for granted the fact that Indigenous ways of knowing produce knowledge differently because they rest upon fundamentally different assumptions. In particular, IKs reject the dichotomy of "nature" and "culture" because IKs collapse the two concepts into an open and continuous relationship (see the literature review). As a result, such a construction of "science" cannot help but marginalize those rational and empirical knowledges of the world that do not rest upon the separation of culture from nature, as well as a belief in objectivity.

In summary, the analysis of the construction of the concept of "science" in *Science 10* reveals that the "science" is constructed in the image of MWS through the following claims: the intention of science is to produce knowledge; scientific knowledge represents the natural world; scientific knowledge is produced by the experimental method in the laboratory. These claims rest upon the assumption of a culture separate from nature and the belief in objectivity; that is, they rest upon assumptions specific to MWS. As such, *Science 10* constructs "science" in a way that is inconsistent (incommensurable) with the concept of multicultural science.

***Science 10* and the Concept of "Scientific Literacy"**

The very first section of *Science 10*, the "Science Program Philosophy and Purpose," outlines "the purpose of the Science 10 curriculum," which is "to help all students, regardless of gender or cultural background, develop scientific literacy" (p. 1). Scientific literacy is, in other words, the focus of the curriculum guide. As such, the concept of scientific literacy regulates what may and what may not be granted curricular space in *Science 10*. The analysis of the construction of scientific literacy in *Science 10* is organized in terms of the *definition* and *content* of scientific literacy, two broad categories I have concocted to facilitate the analysis of scientific literacy. The analysis of the "definition" of scientific literacy attempts to articulate a framework of sorts for the concept of scientific literacy as it is constructed in *Science 10*; the definition is approached first in terms of *Science 10's* vision of scientific literacy and second in terms of the curriculum guide's broad organization of scientific literacy. The analysis of the "content" of scientific literacy attempts to "fill in" the details of the framework, that is, the ideas of science as they are represented in *Science 10*.

The Definition of Scientific Literacy

The analysis of the definition of "scientific literacy" is approached first in terms of its explicit construction (i.e., what it *is*) and second in terms of its more nuanced (and less explicit) construction (i.e., what it is *not*). The "definition" of scientific literacy attempts to name the framework—its vision and organization—into which the inclusion of IKs is attempted.

The very first page of the curriculum guide provides the definition of scientific literacy in *Science 10*:

> Scientific literacy is an evolving combination of the science-related attitudes, skills, and knowledge students need to develop inquiry, problem-solving, and decision-making abilities, to become lifelong learners, and to maintain a sense of wonder about the world around them. A person who is scientifically literate is able to distinguish science from pseudoscience, evidence from propaganda, fact from fiction, knowledge from opinion, theory from dogma, and data from myth and folklore. (p. 1)

Not unexpectedly, the definition of "scientific literacy" is closely linked to definition of "science" vis-à-vis "science-related" attitudes, skills, and knowledge. As the analysis of "science" in *Science 10* outlined above, "science" is constructed according to certain MW claims about the intention, theory, and practice of science, which rest upon the (MWS) assumption of a "culture" distinct from "nature."

Less expectedly, and more interestingly, "science" is also defined in the document in terms of its antithesis, "pseudoscience," which is associated with propaganda, fiction, opinion, dogma, myth and folklore. Here, we can see a dichotomous science/pseudoscience (science/nonscience) binary system at work in the construction of "scientific literacy" in *Science 10*:

Science	**: Pseudoscience**
Evidence	: Propaganda
Fact	: Fiction
Knowledge	: Opinion
Theory	: Dogma
Data	: Myth and Folklore

In essence, this binary is about credibility: "science" is credible because it is based on evidence, fact, etc. (i.e., things that hold up in a court of law, for example, under the rubric of the "reasonable" or "prudent" person); pseudoscience is not credible because it is based on propaganda, fiction, etc. (i.e., things that do not hold up in a court of law, for example, third party voice with first person interpretation). The significance of such a dichotomous system is twofold: first, science is presumed to be either immune to or isolated from propaganda, fiction, etc.; second, rational and empirical knowledges of the world that fail to identify with concepts like evidence, data, etc. are deemed unscientific. IKs, for example, which tend to identify closely with the guiding stories (creation myths) of the cultures to which they belong, would therefore be deemed unscientific according to such criteria. It would appear that such a dichotomy runs counter to multicultural inclusivity. As we can see, the (MW) idea of objectivity is re-presented in the concept "scientific literacy" through the science-pseudoscience dichotomy.

The "Language and Communication in Science" section of the curriculum guide elaborates on the definition of "literacy" within the concept of scientific literacy:

> In order to understand and use new ideas in science, students need to become literate in science. Literacy is "not limited to text…[but] relates to the ability to construe meaning in any of the forms used in the culture to create and convey meaning. (p. 17)

However, several of these forms of communication suggest that "scientific literacy" means being literate in scientists' science:

- "Like scientists, students can learn to vary the formality of their language, especially the use of terminology, when addressing diverse audiences, yet to convey their message without distorting the science or overstating their claims" (p. 17).
- "Students in Science 10 should read to be informed, to perform tasks, and to understand the experiences and thoughts of others, particularly scientists" (p. 18).
- "Scientists spend considerable time and effort building and testing models to further understanding of the natural world. Similarly, when engaging in the processes of science, students are constantly building and testing their own models of understanding of the natural world" (p. 20).

Moreover, students are encouraged to explore the role of the scientist/technologist: "Both female and male students need encouragement to explore non-traditional, as well as traditional, career options in science and technology related fields" (p. 8). We can therefore say that scientific literacy, according to *Science 10*, encourages students not just to behave and communicate like scientists, but also, when possible, to become scientists.

The vision of scientific literacy in *Science 10*, outlined and analyzed above, is most tangibly organized into four units (consisting altogether of 176 learning objectives) that each student must learn. At this point, a brief note on the organization of *Science 10* is necessary.

The broad organization of the *Science 10* curriculum guide can be summarized as follows: The guide consists of four units in total: "Life Science: Sustainability of Ecosystems" (pp. 27-43), "Physical Science: Motion in Our World" (pp. 44-58), "Physical Science: Chemical Reactions" (pp. 59-72) and "Earth and Space Science: Weather Dynamics" (pp. 73-89). Each unit is made up of five foundational objectives, and each foundational objective consists of several learning objectives. As *Science 10* explains, "the foundational objectives describe the broad learning goals of the unit," whereas "the learning objectives describe the specific learning outcomes that each student should achieve" (p. 25). Altogether there are 176 learning objectives (including 21 enrichment learning objectives). The foundational and learning objectives address and direct the matter of teaching the Key Concepts of *Science 10*. The Key Concepts represent the main ideas to be learned by someone who is scientifically literate, as defined by the guide (that is, in terms of MW scientists' scientific literacy). Various Key Questions, Pre-Instructional Questions, and Suggested Teaching Strategies and Activities support the achievement of the objectives (i.e., the learning of the Key Concepts). The objectives therefore appear to constitute the focus of the curriculum guide.

Other aspects of the guide similarly emphasize the objectives. Consider, for example, the relationship between the curricular objectives and the following "broad initiatives that guide the selection of teaching materials, as well as instruction, in the classroom" (p. 5), which includes the Adaptive Dimension, Gender Equity, Resource-Based Learning, Career Development, Assessment and Evaluation:

- "It is through the Adaptive Dimension that the classroom teacher accommodates individual differences of the members of the class. […] **The Adaptive Dimension does not allow the changing or elimination of learning or foundational objectives**" (p. 6; bold in original).
- "Resource-based instruction is an approach to learning in which students use a variety of types of resources to achieve foundational and related learning objectives" (p. 8).
- "This curriculum guide reflects the career development competencies within learning objectives and suggested teaching strategies and activities" (p. 10).
- "Evaluation should be guided by the intended learning outcomes of the curriculum" (p. 10).
- "Foundational objectives form the basis for curriculum assessment and student evaluation" (p. 12).

In other words, various broad initiatives may be included so long as they do not compromise the foundational and learning objectives. The section titled "Implementing Science 10" (pp 13-22) similarly emphasizes the objectives:

- "Teachers need to engage students in authentic activities that are relevant for their students' current lives while addressing the foundational and learning objectives of Science 10" (p. 13).
- "Decision making regarding instructional strategies requires teachers to focus on […] linking ongoing student assessment to learning objectives and processes (p. 13).

Clearly, the foundational and related learning objectives are the structural focus of the curriculum guide.

Each objective, however, is derived from one or more of four Foundational Statements for Scientific Literacy. *Science 10* explains: "In light of the vision for scientific literacy and the need to develop scientifically literate students in Canada, four foundational statements delineate the four critical aspects of students' scientific literacy" (p. 2). These foundational aspects include: "Science, technology, society, and the environment" (STSE), "Knowledge", "Skills," and “Attitudes.” The four foundations define the dimensions of scientific literacy in *Science 10* and therefore set forth a framework of sorts for scientific literacy.

To begin with, the first foundation, STSE “is concerned with the scope and character of science, its connections to technology, and the social context in which it is developed” (p. 3). The roles of science, technology, society, and the environment are taken up in terms of the “nature of science and technology,” “relationships between science and technology,” and “social and environmental contexts of science and technology” (p. 3). Clearly, science and technology are the focus of this story, as it is presented in *Science 10*. The (almost inseparable) association of science with technology is characteristic of MWS, in general. Other elements associated with the STSE narrative include “democracy” and “progress.” As the curriculum guide advocates, “the potential of science to inform and empower decision making by individuals, communities, and society is a central role of scientific literacy in a democratic society” (p. 3). Also, students (and teachers) are encouraged to “recognize the contributions of science to the progress of civilization” (p. 46). The association of science and scientific literacy with “technology,” “democracy,” “progress,” and “civilization” would appear to indicate a MW orientation to this story of science. According to the modern cultural narrative, science and technology play important roles in the pursuit of progress and civilization (which is defined in the West, in large part, by democracy). Indeed, since the time of Thales, modern culture has been preoccupied with the question of what makes up the world as well as the belief that this knowledge can further human progress towards the effecting of all things possible.

The second foundation, Knowledge “focuses on the subject matter of science including the theories, models, concepts, and principles that are essential to an understanding of each science area” (p. 3). The assumption that scientific subject matter be exclusively abstracted (i.e., in the form of theories, models, concepts, and principles) would appear to betray a MW conception of scientific knowledge. *Science 10* elaborates on the nature of such abstractions: “For organizational purposes, this foundation is framed using widely accepted science disciplines” (p. 3). The “widely accepted disciplines” refer to the traditional disciplines of academic MWS—biology, chemistry, and physics. Indeed, each unit is derived from one such discipline: “Sustainability of ecosystems” from biology; “Motion in our world” from physics; “Chemical reactions” from chemistry; and “Weather dynamics” from meteorology (a physics sub-discipline). In contrast to MWS, IKs fragment neither theory from practice nor knowledge in general. The knowledge of science, as *Science 10* approaches the concept, is therefore assumed to consist of the abstracted knowledge (theories, models, concepts, etc.) of academic MWS.

The third foundation, Skills, is constructed in a somewhat conflicting way. At a first glance, this foundation appears to be “concerned with the skills that students develop in answering questions, solving problems and making decisions,” which broadly includes initiating and planning, performing and recording, analyzing and interpreting, and communication and teamwork (p. 4). However, as *Science 10* explains, “while these skills are not unique to science, they play an important role in the development of scientific understandings and in the application of science and technology to new situations” (p. 4). A closer inspection reveals that this foundation addresses the practice of experimental science. To this end, the curriculum guide makes clear its position with respect to teaching experimental (laboratory) skills:

> Laboratory work is often at the centre of scientific research. As such, it should also be an integral component of school science. […] The inquisitive spirit of science is assimilated by students who participate in meaningful laboratory activities. The laboratory is a vital environment in which science is experienced. […] Laboratory science is so integral to the nature of science that it must be included in every science program for every student. (p. 21).

Following the National Science Teachers Association *Science 10* "recommends that a minimum of 40 percent of the science instruction time should be spent on laboratory-related activities in high school science courses" (p. 21). Clearly, the Skills foundation addresses to the practice of MWS, namely, experimental (laboratory) science.

Lastly, the Attitudes foundation "focuses on encouraging students to develop attitudes that support the responsible acquisition and application of scientific and technological knowledge to the mutual benefit of self, society, and the environment" (p. 4). This foundation includes: appreciation of science, interest in science, scientific inquiry, collaboration, stewardship, and safety. The subtlest of all, this foundation reinforces the other three.

The analysis of the four foundational statements for scientific literacy suggests a correspondence with the traditional categories of academic MW "scientific literacy," that is, the theory, practice, and story of MWS (see literature review section, "The Ideology of Preprofessional Science Training and the School Science Curriculum"). Knowledge corresponds to the theory of MWS; Skills corresponds to the practice of MWS; STSE corresponds to the story of MWS; and Attitudes encourages students to enact the knowledge, skills and story of MWS. It should also be noted that the Knowledge foundation corresponds with the traditional categories of academic MWS—biology, chemistry, and physics.

As this subsection demonstrates, *Science 10* defines students' and teachers' "scientific literacy" not only in terms of the science/nonscience binary system, but also in terms of scientists' scientific literacy. The idea that students' and teachers' scientific literacy should be modeled after (MW) scientists' scientific literacy implies that *Science 10* presumes school science can or should imitate scientists' science.

This appears to implicate the ideology of preprofessional science training in the production of *Science 10*. What is more, if we consider that “science” is constructed according to certain MW presuppositions (as demonstrated in the DA of “science”), then the science/nonscience binary system cannot help but construct non-MW knowledges of the world as pseudoscience or as unscientific.

The Content of Scientific Literacy

Whereas the previous section attempted to sketch the framework for scientific literacy (into which IKs are to be included) in *Science 10*, this section attempts to fill in the details of the framework—the ideas that the framework contains. Most explicitly, the ideas of science that *Science 10* (re)presents to its teachers and students can be found in Key Concepts and the objectives that support their acquisition. The objectives, which can be thought of as curricular directives for teachers, are based on the guide’s Key Concepts, which “provide a broad overview of the scientific principles of the unit” (p. 25). More specifically, the Key Concepts serve two purposes: “The first is as a guide indicating the suggested depth of coverage of ideas within Science 10. The second is to provide teachers with a common set of definitions for important concepts within that foundational objective” (p. 25). Thus the Key Concepts (and the objectives that support them) constitute the *content* of scientific literacy—the specific ideas that a “scientifically literate” person should possess—what teachers should teach, and what students should learn—as it is presented in *Science 10*. The structural emphasis on the objectives and the fact that they are based on the Key Concepts demands that both the objectives and Key Concepts be examined more thoroughly. The remainder of this section examines the construction of the Key Concepts, the objectives that support them, and their cultural inclusivity.

The Key Concepts can be roughly organized into one of two categories: concepts that address the ideas of science, as they are presented in *Science 10*, and concepts that address the story of science, as it is presented in *Science 10*. The former category constitutes the majority of the Key Concepts. Concepts concerning the ideas of science have to do with the definitions, theories, principals, etc. of science. Examples include:

- "An *ecological footprint* is a measure of an individual's or a population's impact on the environment" (p. 30).
- "The *slope of a distance-time graph* represents the speed of the object" (p. 56).
- "A *catalyst* is a substance that changes the rate of a chemical reaction but is not changed in the reaction" (p. 69).
- "An *anemometer* is a device used to measure wind speed. Typical units are km/h or knots" (p. 78).

Concepts that address the story of science include:

- "Scientific knowledge is a product of human creativity, critical thinking, and imagination" (p. 46)
- "Scientific knowledge is generated by, and used for, asking questions concerning the natural world" (p. 61).
- "The nature of scientific knowledge and the methods of generating scientific knowledge is different from other forms of knowledge" (p. 85).
- "Science is based on evidence, developed privately by groups or individuals, that is shared publicly with others so that they may attempt to establish the validity and reliability of the evidence" (p. 88).

The Key Concepts that pertain to story of science as knowledge production have been sufficiently reviewed above in the analysis of "science." This subsection therefore focuses on the Key Concepts that pertain to the ideas of science, or its definitions, theories, models, etc. of scientific literacy.

Science 10 refers to these principles and definitions as "operational." The "Vocabulary and Terminology in Science" section explains the meaning of "operational" as it is used in the curriculum guide:

> Students need to recognize that many common words (e.g., force, work, energy, cycle, weight, gravity) have specific meaning when used in the context of science. Students

> should also know that many science terms have operational definitions – that is, the definition describes how to measure the phenomena. (p. 18).

The following examples demonstrate in more detail the curriculum guide's preoccupation with measuring and measurement. More specifically, I have included four examples of Key Concepts (one from each of the four units in the guide) in order to demonstrate the nature of the Key Concepts and their relationship with the learning objectives. (In each case, the Key Concept was selected on the basis that it was central to the unit; for example, *biodiversity* is taken from the "Life Science: Sustainability of Ecosystems" unit; the Key Concept *speed* is taken from "Physical Science: Motion in Our World;" *chemical reaction* from "Physical Science: Chemical Reactions; and *climate change* from "Earth and Space Science: Weather Dynamics.")

Consider, first of all, the Key Concept *biodiversity*, from the foundational objective "Examine biodiversity within local ecosystems" (pp. 32-35). According to *Science 10*, "biodiversity is a measure of the number and variety of a species in an ecosystem" (p. 32). The operational definition of biodiversity is supported by the following two learning objectives:

- "Observe and document a range of organisms to illustrate the biodiversity within a local ecosystem;"
- "Select and use apparatus and materials safely when documenting biodiversity" (p. 32).

Biodiversity is therefore something to be measured and known through measurement—observation and documentation.

Another example of an operational definition is found in the Key Concept *speed*, and its related Key Concepts, "*rate of change*," and "*distance*," from the foundational objective "Investigate the relationship among distance, time, and speed for objects that undergo uniform motion" (p. 51). *Science 10* reads: "*Speed* is the rate of change of distance of an object," where "*rate of change* is a measure of how fast a quantity changes per unit time" and "*distance* is the length of path traveled between two points" (pp. 51-52). The following learning objectives support the Key Concept *speed* (and its related Key Concepts):

- "Collect data about everyday objects that undergo simple linear motion;"
- "Use appropriate instruments such as ticker timers, stopwatches, photographs, or motion detectors to collect data effectively and accurately;"
- "Construct distance-time graphs to represent the uniform motion of everyday objects;"
- "Explain how the concept of rate of change relates to the concept of speed;"
- "Operationally define distance and speed" (p. 51).

Similar to biodiversity, speed is something to be known through measurement.

A third example is found in the Key Concept, *chemical reaction*, from the foundational objective "Observe common chemical reactions in your world" (pp. 61-63). *Science 10* defines a chemical reaction as "a process that involves the formation of new substances with new properties" (p. 61). Two Key Concepts compliment the Key Concept *speed*. First, "*indicators* that provide evidence that a chemical reaction might have taken place include: a colour change, an odour change, the formation of a new substance (precipitate), the emission of a gas, and the release or absorption of heat or light" (p. 61). Second, "energy is lost (released) or gained (absorbed) in every chemical reaction" (p. 61). Furthermore, the following learning objectives support the acquisition of the Key Concept *chemical reaction*:

- "Observe and describe chemical reactions that are important in every day life;"
- "Perform activities to investigate [energy lost/gained in] chemical reactions;"
- "Identify indicators that provide evidence that a chemical reaction has taken place" (p. 61).

As we can see, chemical reactions are understood to the extent that they can be measured in terms of colour change, odour change, presence of a precipitate, energy gained or lost, etc.

Lastly, the Key Concept *climate change*, from the foundational objective "Identify consequences of global climate change" is defined as "a change in the 'average weather' that a given region experiences. Average weather includes all the features we associate with the weather such as temperature, wind patterns, and precipitation” (p. 87). While the practice of measuring weather is largely beyond the scope of the school science classroom, the theory of measuring weather is not. Accordingly, temperature is understood as “a measure of the average speed of molecules” whose “typical units are [degrees Celsius] °C” (p. 78); wind patterns are measured in terms of “wind speed,” whose “typical units are m/s, km/h, or knots,” and “wind direction” (p. 78); precipitation is measured in terms of “water that falls to the ground in liquid or solid form” (p. 82). Like most definitions, climate change is something to be measured.

As the analysis of the content of scientific literacy reveals, *Science 10* demonstrates a preoccupation with measurement as the scientific way of knowing the natural world. Underlying this preoccupation with measurement is the assumption that measurement is the basis for scientific knowledge. This assumption is grounded in the belief that knowledge can (or should) be objective by virtue of its basis in quantitative facts. Most notably, this assumption is particular to MWS. The Key Concepts, and the objectives that support them, therefore reflect the (operational) theory and principles of MWS. In light of the science/pseudoscience dichotomy, the construction of scientific knowledge (and therefore literacy) as based in measurement might invalidate those knowledges of the world that fail to demonstrate such a preoccupation with measurement.

In summary, the DA of “scientific literacy” in *Science 10* demonstrates that the curriculum guide constructs the concept in the image of MWS. As the analysis shows, scientific literacy is defined in terms of a dichotomous science/pseudoscience binary, on the one hand, and MW scientists’ scientific literacy, on the other. The vision of scientific literacy is set forth conceptually in terms of four Foundational Statements for Scientific Literacy. As the analysis demonstrates, the four foundations correspond to the traditional categories of academic MW scientific literacy, that is, the theory, practice, and story of MWS (see the third section of the literature review). The Knowledge foundation in general and the four units in particular are modeled after the traditional categories of academic MWS—biology, chemistry, and physics. The analysis of the content of scientific literacy demonstrates a preoccupation with measurement and operational definitions—as the scientific way of knowing—which would appear to reiterate the suggestion that *Science 10* is informed by the discourse of objectivity, in particular, and MW discourses of science, in general. Unspoken in this construction of scientific literacy are the assumptions that school science can (or should) reflect real world science and that real world science is MWS.

This network of presuppositions regarding the story, theory, practice, etc. of science and scientific literacy, constructed in the image of MWS, works in conjunction with the dichotomous science/pseudoscience binary to create a framework that (either by definition or by implication) positions all non-MW knowledges of the world as unscientific, whether or not they are empirical and rational. The following section, which analyzes the construction of IKs in *Science 10*, explores in more detail the effect of such a framework on the inclusion of Indigenous knowledges.

***Science 10* and the Concept of "Indigenous Knowledge and Ways of Knowing"**

As previously mentioned, *Science 10* is the first document to emerge from the Saskatchewan Learning science curricula renewal process that makes an explicit commitment to the inclusion of "Indian and Métis content and perspectives." To this end, *Science 10* reads: "It is an expectation that Indian and Métis content and perspectives be integrated into all programs related to the education of kindergarten to grade 12 students in Saskatchewan, whether or not there are Indian and Métis students in a particular classroom" (p. 6). As *Science 10* explains, "this begins with understanding and respecting *Indigenous knowledge and ways of knowing*. […] An inclusive science curriculum respects the variety of worldviews that various cultures use to understand and explain their relationships with the natural world" (p. 6). As such, *Science 10* represents the first attempt by Saskatchewan Learning to produce a multicultural school science curriculum document.

This section examines the construction of "Indigenous knowledge and ways of knowing" (also "Aboriginal content and perspectives;" "Indian and Métis content and perspectives") in *Science 10*. The construction of IKs in *Science 10* is taken up in two subsections: the first subsection details how the curriculum guide employs dichotomous binaries in the construction of IKs; the second subsection examines in greater detail how the application of dichotomous binaries to IKs informs their inclusion.

The Construction of Indigenous Knowledges

The location of the definition of IKs is quite telling: "Indian and Métis content and perspectives" is one of several broad initiatives or considerations of "scientific literacy" intended to "guide the selection of teaching materials, as well as instruction, in the classroom" (p. 5). Other broad initiatives include Multiculturalism, Gender Equity, Resource-based Learning, and Career Development. However, as the previous section demonstrates, the broad initiatives of the guide are secondary in importance to the objectives, which are dominated by MWS. Two of the five facets concerned with "integrating Indian and Métis perspectives into the science program" reiterate the point:

- "This approach capitalizes on the responsibility and authority of teachers to adapt instruction in order to be responsive to the interests and needs of their students and local communities, *while still respecting the foundational and related learning objectives*" (p. 6; emphasis added).
- "The creation of cross-cultural units of study […] requires teachers to work collaboratively with members of Indian and Métis communities to choose topics and

> instructional approaches that reflect Indigenous understandings *and that also address curricular objectives*" (p. 7; emphasis added).

Like the other broad initiatives, Indian and Métis content and perspectives may be included insofar as they do not compromise the curricular objectives. The point to be made, however, is that *Science 10* presumes that topics, instructional approaches, and curricular objectives can simultaneously reflect modern *and* Indigenous knowledges.

Closer inspection, however, reveals the presence of a dichotomy in the simultaneous construction of "scientific" and "Indigenous" perspectives. As *Science 10* explains, "Indigenous knowledge and ways of knowing often seem at odds with contemporary, scientific views of knowing. Thus, teachers and students may question why these ways of knowing should be incorporated into and addressed in science courses" (p. 6). (Interestingly, "Indian and Métis Content and Perspectives" is the only broad initiative whose inclusion is questioned in the guide.) The dichotomy to which *Science 10* alludes is made clearer in the following passage:

> Indigenous perspectives are holistic, and focus on understanding concepts at a macro level, and then looking for specific examples that incorporate that knowledge. Inherent in these perspectives is an understanding of the relationships between the living and non-living, and a need to respect cultural values when exploring nature. Contemporary scientific approaches are generally characterized as reductionist, focusing first on the micro level of understanding, then progressing to the major macro concepts and connections. This dichotomy in worldviews creates a challenge for teachers of classes that contain a mix of students of various different heritages. (p. 6)

Furthermore, *Science 10* recommends "identifying Indian and Métis contributions towards *our* understanding of the natural world, and equally valuing Indigenous perspectives and understandings of the natural world along with *scientific* perspectives" (p. 7; emphasis added). The fact that *Science 10* understands IKs and "science" as a "dichotomy in worldviews," and the fact that IKs are constructed as holistic and cultural while scientific perspectives are constructed as contemporary and reductionist, implies that IKs are *not* contemporary (i.e., IKs are primitive) while “science” is accultural (i.e., “science” is objective). IKs are thus positioned as being simultaneously other than science and other than ours. This would appear to contradict the inclusion of diverse knowledges and ways of knowing.

Drawing the on the textual data analyzed so far, we can see that IKs are constructed according to the following dichotomous binary system (parentheses denote terms of the binary that are *implied*):

Scientific	**: Indigenous**
Contemporary	: (Premodern)
Reductionist (micro-to-macro)	: Holist (macro-to-micro)
(Accultural)	: Cultural
Ours	: Theirs
Civilized	: (Primitive)

More specifically, “Indigenous” is explicitly constructed as *theirs*, *holist*, and *cultural* according to the same binary system that constructs “scientific” as *ours*, *civilized*, *contemporary*, and *reductionist*. Implicit in this binary system is the notion (myth) of modern progress. According to this binary system, “Indigenous” is implied to be primitive on account of its association with culture, while “scientific” is implied to be modern on account of its (assumed) dissociation from culture (e.g., demonstrated in the discourse of objectivity). The point to be made with respect to this account of IKs is that IKs do not emerge from the same ontological system that MWS does. More specifically, the ontological system that organizes the world into closed and distinct categorizations, e.g., holistic *or* reductionist, contemporary *or* primitive, theirs *or* ours, etc., is inapplicable to IKs and therefore cannot be used to articulate an understanding of IKs. IKs emerge from a different ontological system than MWS; these ontologies are described (in the literature review) as open and closed. Coupled with the observation that science is constructed in the exclusive image of MWS, we can see that this dichotomous binary system operates to reify the terms that normalize the (imperial) notion of progress that defines our internal neocolonial context and which marginalizes Indigenous knowledges and ways of knowing.

In summary, the analysis of the construction of IKs in *Science 10* demonstrates that IKs are constructed according to a paradox. On the one hand, IKs are constructed as being commensurable with MWS, which is demonstrated explicitly in the assumed relevance of the MWS-based objectives to Indigenous knowledges and contexts. On the other hand, IKs are constructed as being other than science. To begin with, IKs are conspicuously absent from the definition, structure, and content of "scientific literacy" (the construction of which, as the previous section demonstrates, is based in MWS). Where IKs can be found (i.e., as a broad initiative of scientific literacy), the term "Indigenous" is constructed as other than "scientific" according to the same dichotomous binary system that constructs "science" as MWS.

As a result of this paradox, in which IKs are constructed as other than but commensurable with MWS, the attempt to include IKs ranges from openly addressing the challenges of its inclusion to an articulation of IK as inverted "science." The assumption of cross-cultural commensurability in *Science 10*, coupled with fact that "science" is constructed in the image of MWS, would appear to indicate the Eurocentric illusion of benign translatability, which asserts that European (Eurocentric) ideas can cross cultural borders (for example, into Indigenous cultural contexts) without substantial damage or distortion. The following subsection explores in more detail the application of a dichotomous binary ontology to IKs and its effect on their inclusion in *Science 10*.

The Misapplication of Dichotomous Binaries to Indigenous Knowledges

Whereas the previous subsection demonstrated that IKs are constructed according to dichotomous binaries, this subsection more thoroughly explores how it is that the guide misapplies the dichotomous binaries to IKs. In particular, this analysis examines how the reductionism/holism, living/nonliving, science/culture, and nature/culture dichotomies are misapplied to IKs in *Science 10*.

Reductionism/holism. Recall the dichotomous *reductionist/holist* binary (identified in the previous subsection) drawn upon in the simultaneous construction of MWS and IKs: "Indigenous perspectives are holistic, and […] contemporary scientific approaches are generally characterized as reductionist" (p. 6). In this scheme, holism is understood as the inversion of reductionism. Accordingly, Indigenous perspectives "focus on understanding concepts at a macro level, and then looking for specific examples that incorporate that knowledge" while scientific approaches begin by "focusing first on the micro level of understanding, then progressing to the major macro concepts and connections" (p. 6). However, Indigenous knowledge and ways of knowing *do not* begin at the macro level and then incorporate micro level examples as the curriculum guide explains (p. 6) because Indigenous perspectives do not divide their attention between the "micro" and the "macro" when approaching the world.

Holism, in the context of IKs, should not be approached as the inversion of MW *reductionism* (which perhaps explains why this is the only "broad consideration" to question its own inclusion). For example, if the terms "micro" and "macro" must be used in reference to IKs, then it is my recommendation that they be understood as part of a continuum that is never at any time either exclusively microscopic or exclusively macroscopic in focus. Rather, Indigenous knowledges should be approached as holistic because they draw upon an *open* and *continuous* binary ontology. For example, Indigenous knowledges express the nature/culture binary as open and continuous, which is exemplified in the *ecocentrism* of Indigenous thought as well as in the concept of *place* (as explained in the section, "Multicultural Science in the Internal Neocolonial

Context of Canada," in chapter two). In other words, holism in the context of IKs should not be understood according to a dichotomous binary (i.e., holism as the inversion of reductionism; reductionism as the inversion of holism).

Furthermore, it should be noted that the matter of vacillating between macro and micro levels of understanding in modern science is as much a matter of pedagogy as it is epistemology. For example, a Russian science educator I once knew was fond of telling me (and the rest of his students), that Russian school science first focuses on understanding general concepts and then incorporates more specific concepts, while North American school science begins with specific concepts and then moves to more general concepts. In other words, Russian science pedagogy provides a better example of a "holistic" perspective as *Science 10* uses the term, by "focus[ing] on understanding concepts at a macro level, and then looking for specific examples that incorporate that knowledge" (SK Learning, 2005, p. 6).

Typically, MWS organizes the micro and the macro levels of understanding in a linear order of magnitudes, or levels, roughly ranging from the atomic to the galactic. These levels are then fragmented according to their respective disciplines: chemistry, biology, geology, and physics (and their various hybrids). The "micro" level generally refers to those levels smaller in scale than an organism (e.g., human); from smallest to largest, this includes (but is not limited to) subatomic particles, atomic elements, and molecules, which are differentiated as either living (biotic; organic) or nonliving (abiotic; inorganic). The *macro* level generally refers to those levels larger in scale than an organism; from smallest to largest, this includes species, ecosystems, biosphere (planets), solar systems, galaxies, and the universe. An atom, for example, is a system of subatomic components—protons, neutrons, and electrons—bound by electromagnetic and gravitational forces. In another example, an ecosystem is a system of organisms and inorganic matter that are interrelated in a food chain, governed by "laws of competition." The point to be made is that the vacillation between macro levels and micro levels is typical of the *systems perspectives* of MWS.

Living/nonliving. A second dichotomous binary misapplied to IKs carves the world up into either living or non-living. As *Science 10* explains, the sustainability of ecosystems is approached "from a systems perspective," which defines a system as "a set of interrelated components" (p. 32). More specifically, "the living and nonliving components of a biological community and their interrelationships form an *ecosystem*" (p. 32). Non-living or abiotic components of an ecosystem include "sunlight, temperature, wind, water, and rock;" living or biotic components include "animals and plants" (p. 32). The following paragraph explains how *Science 10* approaches the sustainability of ecosystems from a systems perspective:

> Students will document biodiversity as an indicator of the health of ecosystems and investigate the characteristics of population dynamics, within the context of the carrying capacity and limiting factors of ecosystems. This approach provides students with opportunities to explore the interdependence of species and the relationships between organisms and their physical environment. The study of the physical environment will include consideration of the large scale cycling of elements (carbon, nitrogen, and oxygen) in biogeochemical cycles and the bioaccumulation of toxins in food chains and food webs and the consequent effect on the sustainability of ecosystems. (p. 28)

In other words, the various components of the ecological system—from atoms to species—are re-organized into such abstractions as biodiversity, population dynamics, food chains, biogeochemical cycles, and bioaccumulation of toxins.

Indeed, the living/nonliving (biotic/abiotic) binary is prevalent throughout the *Life Science: Sustainability of Ecosystems* unit (p. 29, p. 30, p. 31, p. 32, p. 34, p. 36, p. 37, p. 38, p. 39, p. 41). For example, the living/nonliving dichotomy is a focus of field trips: "The importance of the field trip cannot be understated as it provides students the opportunity to observe all of the interrelationships between biotic and abiotic factors of an ecosystem in a natural setting" (p. 32).

In the event that “a field trip is not feasible, students could view videos or pictures of particular ecosystems and identify examples of biotic and abiotic factors in those ecosystems” (p. 34). What is concerning, however, is this dichotomy is unproblematically extended to various “cultural worldviews” in general: “Students should explore the ways in which various cultures define their relationships with the Earth and all of its inhabitants – living and non-living” (p. 30). For example, *Science 10* assumes that the living/nonliving (biotic/abiotic) binary applies to IKs when it that suggests that “students could compare scientific perspectives of the cyclical nature of matter and the interconnectedness of the biotic and abiotic factors in an ecosystem with Indigenous or other cultural worldviews” (p. 39). As *Science 10* explains, “such a comparison helps to validate multiple perspectives or worldviews” (p. 39). However, as the literature review explains, IKs do not fragment reality into discrete categories of either living or nonliving. As a result, the assumption that such a comparison validates multiple worldviews (e.g., scientific and cultural/Indigenous) is doubtful.

Science/culture. The third dichotomy misapplied to IKs is the science/culture dichotomy (which the reader may recall from the dichotomous science/Indigenous binary system employed in the construction of IKs). Reiterating this dichotomy, *Science 10* constructs “science” as separate from “cultural and intellectual traditions,” though it acknowledges their mutual “social context:”

> The history of science shows that scientific development takes place within a social context. Many examples can be used to show that cultural and intellectual traditions have influenced the focus and methodologies of science, and that science in turn has influenced the wider world of ideas. (p. 3)

Furthermore, the guide explains that “the classroom experience for each student in Science 10 should positively reflect […] not only the contributions to science from various cultures, but also the contexts and connections that it can have to all cultures” (p. 7). As we can see, *Science 10* constructs “science” as distinct from but related (and relevant) to “culture.” Again, while the orientation of this dichotomy may not be problematic for MWS, it runs counter to IKs.

The misapplication of the dichotomous science/culture binary to IKs operates to construct IKs as cultural “others” to science in two ways. First of all, IKs are constructed as “cultural” in the sense that they are defined as knowledge *about* Aboriginal peoples:

> It is an expectation that Indian and Métis content and perspectives be incorporated into all programs related to the education of kindergarten to grade 12 students in Saskatchewan, whether or not there are Indian and Métis students in a particular classroom. *All students benefit from knowledge about the Indian and Métis peoples of Saskatchewan.* It is through such knowledge that misconceptions and bias can be eliminated. (p. 6; emphasis added)

It should be noted, however, that IK is not so much knowledge about Aboriginal people, but rather knowledge of Aboriginal people. Secondly, *Science 10* constructs IKs as “cultural” when it writes, “inherent in these perspectives is […] a need to respect cultural values when exploring nature” (p. 6). Because “science” is not required to “respect cultural values” the reader can only assume that “science” is immune to such “cultural values.” The problem, here, is not that IKs are constructed as “cultural” knowledge because Indigenous knowledges cannot be separated from their cultures (clans, tribes, etc.); rather, the problem has to do with the identification of IKs as cultural when “science” is constructed as accultural. Furthermore, the idea of a science distinct from its culture rests upon the (MW) idea of objectivity.

Implicit in the science/culture dichotomy is the assumption of *one science, many cultures*, of which Indigenous cultures are just one type. So we can say that the construction of “science” as accultural cannot help but construct IKs as other than science (or as unscientific) because IKs self-identify as cultural.

Nature/culture. Lastly, the dichotomous nature/culture binary operates to construct "sustainability" as a feature of both "nature" and "culture," understood as separate entities. This dichotomization, which is characteristic of modern thought, is misapplied to IKs.

The construction of sustainability as a feature or function of "nature" is evident when *Science 10* refers to "the sustainability of ecosystems," "the sustainability of our world," and "the sustainability of our environment" (p. 28). As *Science 10* explains, "nature has its own methods of maintaining limits on populations and keeping an ecosystem in balance" (p. 36). However, the construction of sustainability as a function of the natural world (alone) is problematic for the following reason. Most simply put, sustainability is a matter of (modern humans) learning to live within the carrying capacity of an ecosystem—whether that ecosystem is local or global. Even then, "sustainability" is a very recent phenomenon (crisis) in the history of the earth: in the absence of modern cultures, all plants and animals in general, and *Indigenous peoples* in particular, lived (and continue to live) sustainably, i.e., within the carrying capacities of their environments, and, for that reason, never encountered a "sustainability crisis." So we can say that "sustainability" is a feature of modern culture/s and their inability to live sustainably, which brings us to the second part of the dichotomous construction of sustainability.

Constructed as a function of the human mind, *Science 10* defines sustainability as "a paradigm or worldview that refers to the ability to meet the needs of the present generation without compromising the ability of future generations to meet their needs" (p. 29). According to *Science 10*, "a *paradigm* is the set of experiences, beliefs and values that constitute a way of viewing reality" (p. 30). Two points are worth noting with respect to the construction of sustainability as a paradigm or worldview (i.e., as a function of human culture). First, the paradigm is debated:

- “Some scientists believe that the human population may have grown beyond the Earth’s carrying capacity. Other scientists believe that advances in technology are able to increase the Earth’s carrying capacity” (p. 43).
- “As of mid 2005, the world’s human population is growing at a rate of 200,000 new people each day. Is this sustainable given that there are essentially no new unoccupied lands for people to pioneer, as was true up until the 20th century?” (p. 43).

As *Science 10* explains, “scientific thought and knowledge can be used to support different positions. It is normal for scientists and technologists to disagree even though they may invoke the same scientific theories and data” (p. 30). Second, “sustainability” in *Science 10* is constructed as a theory. To this end, students are expected to “explain changes in the scientific worldview (paradigm shift) of sustainability,” “select and integrate information from various human, print, and electronic sources (government publications, community resources, and personally collected data) with respect to sustainability and the environment,” and “communicate questions, ideas, and intentions, and receive, interpret, understand, support, and respond to the ideas of others with respect to sustainability and the environment” (p. 30). For example, “students are encouraged to develop an action plan that they or members of their community can undertake in order to maintain or enhance the sustainability of our environment at a local, regional, national, or international level” (p. 28). Note that students are “encouraged to develop” but not implement an “action plan.” The rationality behind approaching sustainability theoretically (i.e., as knowledge or information) seems to be that “as students develop these understandings, they are better able to make informed decisions that enhance the sustainability of our world” (p. 28). In this model, the (debated) theory of sustainability is emphasized over the practice of (enhancing) sustainability.

While the fragmentary construction of “sustainability,” is clearly constructed according to MW scientific presuppositions—as a function of the nature/culture dichotomy; as theory rather than practice—the point worth noting is that this construction of sustainability is assumed to be commensurable with IKs. In one example, *Science 10* recommends that students "explore the importance of the concepts of cycles, change, and stability (equilibrium) in ecosystems from scientific and cultural perspectives" (p. 38; emphasis added). In another example, "students could demonstrate their understanding of paradigm shifts and cultural perspectives by writing a story about an environmental issue from a cultural perspective or worldview different from their own" (p. 31).

What is more, the matter of (sub)cultural border-crossing (i.e., between scientific and cultural/Indigenous perspectives) is treated unproblematically. *Science 10* explains the matter of crossing (sub)cultural borders:

> Some researchers believe that learning science requires many students to cross borders from the subcultures of their families and communities into the subculture of science and of school science (Aikenhead, 1996). Teachers can facilitate this border crossing by communicating with parents that school science includes more than the recitation of facts; rather, it requires active involvement by students in developing their own understanding of the natural world that respects personal cultural beliefs and scientific principles. (p. 7)

This conception of (sub)cultural border-crossing fails to account for differences (incommensurabilities) between various scientific and cultural beliefs while at the same time reproduces the science/culture dichotomy. For example, *Science 10* takes for granted that a student's "understanding of the natural world" might not simultaneously respect "personal cultural beliefs and scientific principles," leaving the student to deal with any incommensurabilities on his or her own. However, as the literature review demonstrates, (sub)culturally specific presuppositions do not necessarily cross (sub)cultural borders (and rarely do, by my estimation).

One of few examples that explicitly demonstrate the assumed commensurability of MWS ("science") and IKs in *Science 10* involves the paradigm of "sustainability" and the Indigenous "seven generations" philosophy. *Science 10* reads:

> Sustainability is a way of understanding and interacting with the world that enables society to 'meet the needs of the present without compromising the ability of future generations to meet their own needs' (*Our Common Future, United Nations*, 1987). This representation of the paradigm of sustainability echoes the 'seventh generation' philosophy of some First Nations, which suggests leaders consider the effects of their actions on their descendants through the seventh generation in the future. (p. 30)

However, this approach to "the paradigm of sustainability" is anthropocentric (human-centered) because only human needs are considered. Put differently, "descendants" (and therefore "family") is considered in anthropocentric terms. Moreover, this anthropocentrism is extended to "the 'seventh generation' philosophy of some First Nations" in the recommendation that leaders consider the effects of their actions for the sake of their (human) descendants, or, alternatively, to meet the needs of the present without compromising our descendants' ability to meet their (future) needs.

The "human-centredness" of this interpretation of the "seven generations" philosophy becomes more apparent when compared to Orel Lyons' (1984) ecocentric explanation of the philosophy (which is therefore worth quoting at length):

> And each generation was to raise its chiefs and to look out for the welfare of the seventh generation to come. We were to understand the principles of living together. We were to protect the life that surrounds us, and we were to give what we had to the elders and to the children. The men were to provide, and the women were to care for the family and be the center, the heart of the home. And so our nation was built on the spiritual family, and we were given clans… the Turtle, the Eagle, the Beaver, the Wolf, the Bear, the Snipe, the Hawk, all of whom were symbols of freedom. Our brothers the Bears, the Wolves, and the Eagles are Indians; they are natives, as we are. We went to Geneva, the six nations, the great Lakota nation, as representatives of indigenous people of the western hemisphere, and what was the message that we gave? 'There is a hue and a cry for human rights,' they said, 'for all people,' and the indigenous people said, 'What of the rights of the natural world? Where is the seat for the Buffalo or the Eagle? Who is representing them here in this forum? Who is speaking for the waters of the earth? Who is speaking

> for the trees and the forests? Who is speaking for the Fish, for the Whales, for the Beavers, for our children? We are indigenous people to this land. We are like a conscience; we are small, but we are not a minority; we are the landholders, we are the land keepers; we are not a minority, for our brothers are all the natural world, and for we are by far the majority. It is no time to be afraid. There is no time for fear. It is only time to be strong, only a time to think of the future and to challenge the destruction of your grandchildren.' (quoted in Cajete, 1994, p. 76)

As this passage explains, every generation needs to look after the welfare of "all the natural world" (e.g., "the rights of the natural world") which includes "the water of the earth" as well as "the life that surrounds us," (e.g., the trees and the forests, the turtle, the eagle, the beaver, the wolf, the bear, the snipe, the hawk, the buffalo, the fish, the whales, etc.). In the Indigenous view, the cultural world is an indistinguishable part of the natural world.

The analysis of the nature/culture binary demonstrates that the dichotomy is problematic to the inclusion of IKs not only because it constructs Indigenous knowledges as other than science, but also because the dichotomy is misunderstood to be a relevant conceptual category of IKs. Furthermore, the anthropocentrism inherent to the dichotomous binary can be demonstrated in the (MW) construction of sustainability and its assumed commensurability with IKs. This demonstrates two presuppositions with respect to the inclusion of IKs in *Science 10*: first, the inclusion rests upon the presupposition that "science" (constructed in the image of MWS) is distinct from but commensurable with IKs; second, the transition between "scientific" to "cultural" worldviews or perspectives is not a problematic process.

In summary, this analysis has examined several discrete binaries more thoroughly in order to explore how they inform the inclusion of IK in *Science 10*. The dichotomies examined, which include reductionism/holism, living/nonliving, science/culture, and nature/culture, are all mistakenly assumed to apply to Indigenous knowledges and ways of knowing. In this way, the dichotomies operate to marginalize IKs on the basis of their irrelevance to IKs. Consider, for example, the construction of the concept of sustainability according to the dichotomous nature/culture binary, as a feature of both ecosystems and the human mind. Interestingly, several of the misapplied binaries operate to explicitly dichotomize and therefore marginalize IKs. The reductionist/holist dichotomy operates to incorrectly construct IKs as the holistic inverse of reductionist science. The science/culture dichotomy (which rests upon the assumption that "science" can be separate from "culture") operates to construct IKs as the cultural other to (objective) science. Lastly, and perhaps most significantly, the nature/culture dichotomy is examined in the construction of IKs as well as "sustainability." The dichotomous nature/culture binary is drawn upon to construct IKs as cultural (an idea with which they self-identify) and "science" as accultural (in the image of MWS, which it is not, as critics have long since illustrated). The point to be made is that dichotomous binaries do not cross cultural borders into the domain of IKs. As the literature review explains, IKs emerge from and reflect an open and continuous binary ontology. As a result, these three dichotomies operate construct IKs as other than science, which is defined in exclusively MW terms.

The misapplication of a dichotomous binary ontology to IKs reveals that *Science 10* constructs IKs in relation to science according to a paradox: *IKs are constructed as being commensurable with but other than "science." Science 10* is grievously wrong on both accounts. While it is correct to say that *IKs are other than MWS* because the two traditions rest upon fundamentally divergent presuppositions (that may be *incommensurable*), it is *not* correct to say that *IKs are other than science* because IKs *are* scientific (i.e., IKs are *ecocentrically* empirical and rational). That said, I believe that the paradoxical construction of IKs is significant because it demonstrates that IKs are misunderstood by virtue of their (mis)interpretation through MW lenses.

Discourse Analysis Summary

This chapter takes up the inclusion of IKs in *Science 10* in terms of the construction of concepts "science," "scientific literacy," and "Indigenous knowledge." The focus of the DA is the construction of IKs in relation to "science" and "scientific literacy."

The DA of *Science 10* demonstrates that the concept of "science," which is constructed as singular, rests upon several presuppositions characteristic of (academic) MWS. According to *Science 10*, the intention of science is to produce knowledge about the natural world, which is abstracted from the natural world (by the scientific-cultural world), in the context of the experimental laboratory. This model of science rests upon the dichotomous nature/culture binary, which presupposes that culture is separate from nature, which is characteristic of MWS, and which is not commensurable with IKs. As such, *Science 10* constructs "science" in the exclusive image of MWS.

The concept of "scientific literacy" in *Science 10* is taken up in terms of its definition and content. The DA reveals that "scientific literacy" is defined according to a dichotomous science/pseudoscience binary system based in MWS. Not surprisingly, scientific literacy is defined in terms in terms of (MW) scientists' scientific literacy. To this end, four Foundational Statements delineate the concept of scientific literacy. The foundations include STSE, Knowledge, Skills, and Attitudes; the first three of which correspond to the story, theory, and practice of MWS, while the fourth merely reinforces the first three. The DA of the content of scientific literacy reveals an emphasis on the measurements and measuring of the world, which reiterates and reproduces modern Western knowledge and ways of knowing (i.e., operationalism). Like the concept "science," *Science 10* constructs "scientific literacy" in the image of MWS. As a result of (1) the construction of scientific literacy in the image of MW scientists' scientific literacy in conjunction with (2) the construction of scientific literacy in relation to a dichotomous science/pseudoscience binary system, *Science 10* creates a framework that cannot help but construct non-MW knowledges of the world as unscientific.

The DA of the construction of "Indigenous knowledge and ways of knowing" reveals that IKs are constructed according to a paradox: IKs are constructed as commensurable with but other than "science," which is constructed in the image of MWS. On the one hand, IKs are constructed according to a dichotomous scientific/Indigenous binary system that dissociates "scientific" from culture, while associating "scientific" with *contemporary*, *civilized*, *reductionist*, and *ours* and "Indigenous" with *holist*, *cultural*, and *theirs*. On the other hand, the content of the curriculum guide (i.e., the Key Concepts and the foundational and related learning objectives), which is based in MWS, is assumed to be commensurable with IKs. As the analysis of the construction of IKs in *Science 10* demonstrates, the misapplication of dichotomous (MW) binaries to IKs operates to preclude the inclusion of IKs in two ways. First, the terms of the dichotomies that are applied to IKs position IKs as other that science, e.g., holistic (vs. reductionist), cultural (vs. objective), mythical (vs. factual), and so on. Second, IKs emerge from open and continuous binary ontologies and are therefore incommensurable with concepts that emerge from a dichotomous binary ontology, e.g., dichotomies such as micro/macro, living/nonliving, science/culture, and nature/culture.

Whether IKs are dichotomized or misrepresented, the point to be made is that IKs are misunderstood. As the DA of the inclusion of IKs in *Science 10* demonstrates, the commensurability of science (MWS) and IKs is taken for granted. In failing to adequately accommodate the incommensurabilities that define the space between IKs and MWS—two parallel knowledges of and ways of knowing the world—*Science 10* precludes the inclusion of

IKs when “science” and “scientific literacy” are defined according to ethnocentric (MW/Eurocentric) philosophical presuppositions.

CHAPTER FIVE

CONCLUSION

The Intentions of the Research

Broadly speaking, this research aimed to identify and explore the problems inherent to the matter of multicultural (cross-cultural) science in order to better understand the nature of multicultural (cross-cultural) school science curriculum development. As the first example of science curriculum produced since Saskatchewan Learning has made explicit its commitment to the inclusion of IKs (Saskatchewan Learning, 2005b, p. 4), *Science 10* (Saskatchewan Learning, 2005a) offers itself as an indicator of the state of multicultural (science) curriculum development in the internal neocolonial context of Saskatchewan, Canada. As the curriculum guide explains, "the philosophy and spirit of science education in Saskatchewan is reflected in this curriculum, in the documents that support the new curriculum, and in materials designed and utilized for implementation" (p. 1). In an effort to understand the inclusivity of *Science 10*, this study examines the discursive construction of the concepts "science," "scientific literacy," and "Indigenous knowledge and ways of knowing" (also "Indian and Métis content and perspectives;" "Aboriginal content and perspectives").

The literature review takes up four key issues inherent to the matter of multicultural science in the internal neocolonial context of Saskatchewan, Canada: internal neocolonialism, multicultural science, the ideology of preprofessional science training, and the Eurocentric illusion of benign translatability. The first two concepts are important because they inform the broader context of *Science 10* (and the inclusion of IKs). The second concepts are important because they represent two significant barriers to the inclusion of IKs (in any curriculum).

Tejeda, Espinoza, and Gutierrez' (2003) theorization of *internal neocolonialism* is important because it draws attention to the cognitive and ideological forces that act through media such as curricula to (re)produce the imperial discourses that sustain the material domination, oppression, and exploitation of Indigenous peoples. Drawing on postcolonial studies of science (Harding, 1998; 2006; Cajete, 2000b; Knudtson & Suzuki, 2001) and cultural studies of science and science education (Aikenhead 2006; Hadi-Tabassum, 2001; Ogawa, 1995), "science" is defined as a culturally specific empirical and rational (systematic) knowledge of the world. Importantly, this conception of science (as multicultural) accommodates the incommensurabilities of MWS and IK, which I approach in terms of their divergent histories, politics, epistemologies, and ontologies. I suggest that IKs are more likely to support sustainable, ecocentric, practical, and inclusive practices, while MWS has tended to support practices that are unsustainable, anthropocentric (human-centred), abstract (theoretical), and dichotomous. Because of these differences, it can be difficult to approach IKs from a MW (Eurocentric) worldview.

In particular, the matter of multicultural (cross-cultural) school science is troubled by the ideology of preprofessional science training (Aikenhead, 2006, pp. 13-15) as well as the Eurocentric illusion of benign translatability (Battiste & Henderson, 2000, pp. 79-82). The ideology of preprofessional science training—the ideology that traditionally dominates school science—encourages students to enact MWS in the pursuit of becoming MW scientists. The Eurocentric illusion of benign translatability maintains that Eurocentric (modern Western) worldviews can be not only translated but also translated without substantial damage or distortion. In the context of (school) science, the Eurocentric illusion of benign translatability maintains that MWS is applicable across cultural borders. Both the ideology of preprofessional science training and the Eurocentric illusion of benign translatability contradict the concept of multicultural science because they both rest upon the assumption that MWS is universal.

The methodology of discourse analysis (DA) employed in this research is inspired by Kieran Egan's (2005) paper *Letting our presuppositions think for us*. In his paper, Egan explains that because the claims we make rest on philosophical presuppositions, "it would be an absurd strategy to deal only with the claims and ignore the presuppositions because it may well be that our disagreements are at the level of presupposition," which is "usually the case when it comes to arguments or decision-making about the curriculum" (p. 1). In the context of multicultural science curriculum development, I believe the concept of multicultural science is often rendered meaningless because the claims and presuppositions of otherwise parallel ethnosciences (e.g., MWS and IK) are mistakenly assumed to cross cultural borders.

The DA of *Science 10* examines the inclusivity of the guide in terms of the discursive construction of the concepts of "science," "scientific literacy," and "Indigenous knowledge and ways of knowing." More specifically, the construction of "Indigenous knowledge and ways of knowing" is examined in relation to the construction of "science" and "scientific literacy." The three concepts are examined according to, first, the claims that construct them and, second, the presuppositions upon which the claims rest. From the findings of the research, the discourses drawn upon in the production of *Science 10* (and the inclusion of IKs therein) will be identified.

Implications

The research findings demonstrate that *Science 10* takes for granted the problem of multicultural (cross cultural) science curriculum development. In large part, this is because *Science 10* misunderstands IKs, which can be demonstrated in the assumption of cross-cultural translatability: IKs are incorrectly assumed to be commensurable with "science," which is constructed in the exclusive image of MWS. A significant part of the problem of multicultural or cross-cultural science has to do with the fact that IKs (in the context of academics) use many of the same terms as MWS (e.g., "science," "nature," "culture," "holistic") but with very different meanings. For example, IKs are "holistic" in the sense that they begin and end with the whole of creation, but not in the sense that they represent the inverse of reductionism. Similarly, IKs are "cultural" because the people hold the knowledge, and not because they fall short of the standards of objectivity (which is a distinctly Western ideal). As well, IKs can be described as "mythical" because storytelling plays a central role in connecting people to place, not because they are fictional. In short, IKs cannot be accurately described by the same dichotomous binary ontology that constructs MWS because IKs emerge from an entirely different (open and continuous) binary ontology. This would appear to indicate that *Science 10* is guilty of the Eurocentric illusion of benign translatability. Most importantly, I believe that any attempt to understand IKs through such a dichotomous ontological framework will only result in cognitive imperialism and the continued marginalization of IKs.

The fact that the curriculum guide constructs "science" and "scientific literacy" in the exclusive image of MWS reveals in *Science 10* the presupposition that MWS *is* "science" (or, alternatively, that MWS is *universal*). The presupposition of one science (i.e., MWS) coupled with the fact of one world effectively allows for only one interpretation of the natural world. The assertion of one world, one interpretation, and one science reflects what Sandra Harding (2006) refers to as the *unity of science thesis*, which she explains as a set of three interrelated assumptions:

> According to the unity argument, there is one world, one and only one possible account of it, and one unique science that can capture that one truth most accurately reflecting nature's own order. Less visible in most articulations of the unity thesis is a fourth

> assumption: there is just one group of humans, one cultural model of the ideal human, to whom nature's true order could become evident. (p. 121)

Indeed, *Science 10* recognizes many various cultures. And so, the fact of one world coupled with the assumption of one interpretation and one science of the world operates with the recognition of many cultures ("multiculturalism"), in conjunction with the science/pseudoscience and scientific/Indigenous binary system, to imply that modern cultures (vis-à-vis MWS) are the cultural model of the ideal human to whom nature's true order could be become evident.

As this demonstrates, the unity of science thesis renders the concepts "multiculturalism" and "multicultural science" not just inert, but also complicit with cognitive imperialism! By comparison, a truly multicultural understanding of "science" would allow for multiple scientific interpretations of the world we share. The following recommendations, which are directed at policy makers, curriculum writers, and science teachers, are intended to address the misunderstanding of IKs from the perspective of modern Western (Eurocentric) worldviews, in general, and within the context of school science, in particular.

First, if MWS and IKs are to be understood as being commensurable, it is should be on the basis that both culturally-specific knowledges of the world are empirical (observation-based) and rational (systematic; logical; philosophical) according to their own standards. As a result of their respective cultural specificity (e.g., each knowledge tradition emerges from a different binary ontology), each expresses different (and sometimes incommensurable) facts, which are based in different (and sometimes incommensurable) rationalities. Put differently, in language consistent with the analysis of *Science 10*, MWS and IKs make different (and sometimes incommensurable) claims because MWS and IK rest upon different (and sometimes incommensurable) philosophical assumptions.

Second, with the exception that MWS and IK are both scientific, little else between the two knowledge systems should be taken for granted as being commensurable. As such, the process of multicultural curriculum development should start from the premise that MWS and IKs are philosophically divergent. Acknowledging the incommensurability of MWS and IKs is recommended as a strategic attempt to deal with the Eurocentric illusion of benign translatability from the outset of curriculum development. Importantly, this is not to say that the two scientific traditions cannot arrive at the same conclusions (e.g., facts, theories) about the world. Rather, it is to say that MWS and IKs are unlikely to arrive at the same conclusions about the world because they are preoccupied with fundamentally different questions. For example, since its inception, MWS has been concerned with the question of what makes up the world, while IKs have, from the dawn of time, been concerned with the question of how to maintain the land, and all of the life that depends upon it.

Since both knowledge types are scientific, both MWS and IKs should have a place in school science programs and curricula. However, the scientific content of each knowledge system is fundamentally different and therefore cannot be the basis for inclusion. Unless the fundamental incommensurability existing between Indigenous and modern sciences and their ontologies is first acknowledged, it is my opinion that the development of legitimately *multicultural* curricula will be impossible. Furthermore, I believe failure to acknowledge this fundamental incommensurability will advance the unity of science thesis and therefore render any attempt to develop multicultural curricula complicit with cognitive imperialism. Simply put, modern Western science provides an inadequate framework for multicultural (cross-cultural) curricula development because the categories upon which it draws are not broad enough to accept divergent knowledges of nature.

Instead, thematic content would provide a better bridge than scientific content between the two, which is culturally specific (and therefore cannot be translated without significant damage or distortion, as the misapplication of dichotomous binaries to IKs demonstrates). Two potential bridges already exist within *Science 10*, though they require expansion in order to meaningfully accommodate IKs and thus actualize authentically multicultural (cross-cultural) school science curricula. The concept of "sustainability" could be a potential bridge, if the sustainability unit in the guide ("Life Science: Sustainability of Ecosystems") was understood to represent MWS in particular and not "science" in general. Indeed, as the literature review explains, IKs emerge from philosophies concerned with (not to mention histories that demonstrate) "sustainability." If the Western ecological concept of "sustainability" represents the "modern" side of the bridge, the Indigenous concept of *place* represents the other side of the bridge. Understanding this bridge from a modern Western perspective requires a shift in thinking from land-as-object to land-as-relation. The STSE foundation, which focuses on the narrative aspect of "science," could provide a second bridge, provided that it is expanded to include alternative cultural narratives, such as those narratives that inform IKs, which do not identify with the modern narrative of progress (development; civilization). More specifically, the concept of STSE would have to be expanded to include the concept of *place*.

Though it is not addressed in *Science 10*, "food" provides another context that could simultaneously address MWS (e.g., the history and practice of chemical-industrial food) and IKs (e.g., a history of corn). Glen Aikenhead's (2006) concept of "everyday science" provides perhaps another point of entry to the (potential) development of multicultural (cross-cultural) science programming and curricula.

All of these potential bridges are, of course, only suggestions for the integration of MWS and IKs within the same program or course. Taken together, they all try to make the same point: Unless the definition of “science” is expanded to be “multicultural” (as I attempt to do in the literature review), all efforts to include IKs with school science programs and curricula will be rendered ineffective and meaningless. My personal redefinition of “science” as multicultural is indebted to the twin projects of postcolonial studies, the simultaneous deconstruction of MW/Eurocentric thought (and relatedly, MWS) and the reconstruction of IKs.

In conclusion, in the interest of recognizing and including IKs within school programming in an internal neocolonial context, it is my recommendation that courses based in IKs should receive science credits in schools without necessarily having to follow the standard science curricula. In other words, IK (or Native science) courses should follow self-determined curricula. This is not to suggest against the development of multicultural or cross-cultural (science) curricula, but rather, to strongly advise caution with respect to the matter of integrating the two (differently) scientific traditions.

As the literature review explains, MWS and IKs are incommensurable in ways that inhibit understanding across cultural borders, and, as this research demonstrates, mandating IKs to follow the standard science curriculum constitutes cognitive imperialism and therefore reinscribes our neocolonial context. As such, it is also the recommendation of this research that the integration of IK and MWS within the same course or curriculum guide begin with acknowledging *the incommensurability of MWS and IKs.* Furthermore, the space between (or overlapping) MWS and IK needs to be further explored. In the event that the incommensurability of MWS and IKs is acknowledged, the meaningful integration of the two ethnosciences within the same course or curricular document may yet demand a structural separation of sorts, say, in separate units or themes, or different objectives. Indeed, my own cross-cultural (multicultural) education consisted of courses that addressed MWS and IKs separately. Clearly, the matter of understanding and developing cross-cultural (multicultural) science programs and courses requires further research. Aikenhead and Mitchell (2011) provide such research in their book *Bridging cultures: Indigenous and scientific ways of knowing nature*, which examines the matter of preparing and implementing science curricula that recognize Indigenous knowledge as a foundational way of understanding the physical world.

References

Aikenhead, G. S. (1996). Science education: Border crossing into the subculture of science. *Studies in Science Education, 27*, 1-51.

Aikenhead, G. S. (1997). Toward a First Nations cross-cultural science and technology curriculum. *Science Education, 81*(2), 217-238.

Aikenhead, G. S. (2001). Integrating western and Aboriginal sciences: Cross-cultural science teaching. *Research in Science Education, 31*(3), 337-355.

Aikenhead, G. S. (2002). Cross-cultural science teaching: *Rekindling Traditions* for Aboriginal students. *Canadian Journal of Science, Mathematics and Technology Education, 2*(3), 287-304.

Aikenhead, G.S. (2006). *Science education for everyday life: Evidence-based practice*. New York: Teacher's College, Columbia University.

Aikenhead, G. S. & Huntley, B. (1999). Teachers' views on Aboriginal students learning western and Aboriginal science. *Canadian Journal of Native Education*, *23*(2), 159-175.

Aikenhead, G. & Mitchell, H. (2011). *Bridging culture: Indigenous and scientific ways of knowing nature*. Don Mills, Ontario: Pearson Education.

Ashcroft, B., Griffiths, G., & Tiffin, H. (2000). *Post-colonial studies: The key concepts*. New York: Routledge.

Battiste, M. & Henderson, J. (2000). *Protecting Indigenous knowledge and heritage*. Saskatoon, SK: Purich Publishing Ltd.

Battiste, M. (2000). *Reclaiming Indigenous Voice and Vision*. Vancouver: UBC Press.

Bauer, H. (1992). *Scientific literacy and the myth of the scientific method*. Chicago: University of Illinois Press.

Cajete, G. (2000). *Native science: Natural laws of interdependence*. Don Diego, Sante Fe, New Mexico: Clear Light Publishers.

Casey, E. (1996). How to get from space to place in a fairly short stretch of time: Phenomenological protegomena. In Feld, Steven, & Basso (Eds.), *Senses of place* (pp. 13-52). Sante Fe, New Mexico: School of American Research Press.

Christie, M.J. (1991). Aboriginal science for the ecologically sustainable future. *Australian Science Teachers Journal, 37*(1), 26-31.

Deboer, G.E. (1991). *A history of ideas in science education*. New York: Teachers College Press.

Egan, K. (2009). *Letting our presuppositions think for us*. 13.05.09. www.educ.sfu.ca/kegan/Presuppositions.html

Eisner, E. W. (1991). Rethinking literacy. *Educational Horizons, 69*, 120-128.

Frederick, W.A. (1991). Science and technology education: An engineer's perspective. In S.K. Majumdar, L.M. Rosenthal, P.A. Rubba, E.W. Miller, & R.F. Schmalz (Eds.), *Science education in the United States: Issues, crises and priorities* (pp. 386-393). Easton, PA: The Pennsylvania Academy of Science.

Hadi-Tabassum, S. (2001). Defining a theoretical framework for multicultural science, In S. Maxwell Hines (Ed.), *Multicultural Science Education: Theory, Practice, and Promise*, 187-201. New York: Peter Lang.

Kawagley, O. (1995). *A Yupiaq worldview*. Prospect Heights, IL: Waveland Press.

Knudtson, P. & Suzuki, D. (2001). *The wisdom of the elders*. Toronto, Canada: Stoddart.

Layton, D. (1981). The schooling of science in England, 1854-1939. In R. MacLeod & P. Collins (Eds.), *The parliament of science* (pp. 188-210). Northwood, England: Science Reviews.

Lehtonen, M. (2000). *The cultural analysis of texts*. London: SAGE Publications Ltd.

MacLure, M. (2003). *Discourse in educational and social research*. Buckingham, PA: Open University Press.

McKenzie, M. (2006). Three portraits of resistance: The (un)making of Canadian students. *Canadian Journal of Education, 29*(1), 199-222.

McKinley, E. (1996). Towards an Indigenous science curriculum. *Research in Science Education, 26*, 155-167.

Michell, H., Vizina, Y., Augustus, C., & Sawyer, J. (2008). *Learning Indigenous science from place: Research study examining Indigenous based science perspectives in Saskatchewan First Nations and Métis community contexts*. Saskatoon, SK: Aboriginal Education Research Centre. ISBN: 978-0-9810855-0-0

Millar, R., & Osborne, J. (Eds.). (1998). *Beyond 2000: Science education for the future.* London: King's College, School of Education.

Ogawa, M. (1995). Science education in a multi-science perspective. *Science education*, *79,* 583-593.

Quinn, D. (1995). *Ishmael*. New York: Bantam/Turner Books.

Rogers, R. (2004). *An introduction to critical discourse analysis in education*. Mahwah, NJ: Lawrence Erlbaum Associates, Publishers.

Rogers, R., Malancharuvil-Berkes, E., Mosley, M., Hui, D., & O'Garro Joseph, G. (2005). Critical discourse analysis in education: A review of the literature. *Review of Educational Research, 75*(3), 365-416.

Saskatchewan Education. (2000). *Core curriculum: Principals, time allocations, and credit policy*. Regina SK: Author.

Saskatchewan Learning. (2005a). *Science 10 curriculum guide*. Regina, SK. Author.

Saskatchewan Learning. (2005b). *Aboriginal education provincial advisory committee: Priorities report 2005-2007*. Regina SK: Author.

Semali, L.M., & Kincheloe, J.L. (1999). *What is indigenous knowledge: Voices from the academy*. New York: Falmer Press.

Stanley, W. & Brickhouse, B. (2001). Teaching sciences: The multicultural question revisited. *Science Education, 85*, 35–49.

Tejeda, C., Espinoza, M., & Gutierrez, K. (2003). Toward a decolonizing pedagogy: Social justice reconsidered. In P.P. Trifonas (Ed.), *Pedagogies of difference: Rethinking education for social justice*. New York: Routledge Press.

Willinsky, J. (1994). After 1492-1992: A post-colonial supplement for the Canadian curriculum. *Journal of Curriculum Studies, 26*(6), 613-629.

Young, R. J. C. (2004). *White mythologies*. New York: Routledge.

Ziman, J. M. (1984). *An introduction to science studies: The philosophical and social aspects of science and technology*. Cambridge: Cambridge University Press.